LEVEL II MEMORANDUM

DATE: June 29, 2012

TO: Chief Academic Officers, Montana University System

FROM: Sylvia Moore, Deputy Commissioner for Academic, Research, & Student Affairs
John Cech, Deputy Commissioner for Two-Year & Community College Education

RE: Level II Submission Items

The campuses of the Montana University System have proposed new academic programs or changes under the Level II approval process authorized by the Montana Board of Regents. The Level II proposals are being sent to you for your review and approval. If you have concerns about a particular proposal, you should share those concerns with your colleagues at that institution and try to come to some understanding. If you cannot resolve your concerns, you need to raise those concerns at the Chief Academic Officer's conference call on **July 3, 2012**. Issues not resolved at that meeting should be submitted in writing to OCHE by noon on **Friday, July 6**. That notification should be directed to Summer Marston, Assistant to the Deputy Commissioners. If Summer does not hear from you, in writing, by **noon on July 5**, OCHE will assume that the proposals have your approval.

The Level II submissions are as follows:

Montana State University-Bozeman:

- Doctor of Nursing Practice ITEM # 156-2001-C0812 | Request Form | Curriculum Proposal
- Latin American and Latino Studies Option ITEM #156-2002-C0812 | Request Form | Curriculum Proposal
- Minor in Materials ITEM #156-2003-C0812 | Request Form | Curriculum Proposal

The University of Montana-Missoula:

- Collaborative Ph.D. in Materials Science between The University of Montana–Missoula, Montana Tech of The University of Montana, and Montana State University–Bozeman ITEM #156-1003-C0812 | Request Form | Curriculum Proposal | Appendices | Letters of Support

August 6, 2012

ITEM 156-2001-C0812
Doctor of Nursing Practice

THAT

The Board of Regents of Higher Education authorizes Montana State University-Bozeman to establish a Doctor of Nursing Practice degree.

EXPLANATION

Montana State University-Bozeman requests approval to offer a Doctor of Nursing Practice (DNP) degree. Students who have a baccalaureate degree in nursing or a master's degree in nursing will be eligible for admittance to this program. This new program is congruent with the recommendation of the American Association of Colleges of Nursing (AACN) who voted in 2004 to support moving the current level of preparation necessary for advanced practice nurses (nurse practitioners, midwives, clinical nurse specialists, and certified nurse anesthetists) from the master's degree to the doctorate by the year 2015. The College of Nursing currently offers three master's degree options, two of which are for advanced practice nurses (Family Nurse Practitioner and Family Psychiatric Mental Health Nurse Practitioner). The college is proposing to no longer offer the two nurse practitioner options at the master's level; these options will be moved to the doctoral level. The DNP degree is one of two terminal degrees currently offered by the profession of nursing with the other being the PhD. The DNP is a practice-focused degree and prepares experts in advanced clinical practice while the PhD is a research-focused degree designed to prepare nurse scientists and scholars. Currently, the College of Nursing offers no doctoral degree.

The DNP program will meet the needs of baccalaureate and master's prepared nurses who seek to earn a degree on par with the recommendation of the national organization. They will not have to leave the state to earn the degree that is becoming the standard for advanced preparation of nurses.

Consumers will be well served by graduates of this program in that the DNP prepared nurse is an excellent fit for a rural state such as Montana. With approval of this degree, MSU-Bozeman will begin preparing and graduating nurses with a clinical doctorate. Simultaneously, Montana's citizens will begin to receive care from highly skilled doctorally prepared professional nurses who can provide quality, primary care for children, adults, and the elderly. Additionally nurses with a DNP degree will have skills in the areas of organization and systems leadership, clinical scholarship, information systems/technology and patient care technology, health care policy, interprofessional collaboration, clinical prevention and population health. These additional competencies will result in highly educated practitioners who will not only provide expert direct primary care, but also will be leaders in the improvement and transformation of health care – both of which are desperately needed in Montana's rural remote areas.

ATTACHMENTS

Level II Request Form
Curriculum Proposal

Montana Board of Regents

LEVEL II REQUEST FORM

Item Number: **156-2001-C0812** Meeting Date: **August 6, 2012**

Institution: Montana State University – Bozeman CIP Code: 51.3818

Program Title: Doctor of Nursing Practice

Level II proposals require approval by the Board of Regents.

Level II action requested ***(place an X for all that apply and submit with completed Curriculum Proposals Form):***

Level II proposals entail substantive additions to, alterations in, or termination of programs, structures, or administrative or academic entities typically characterized by the (a) addition, reassignment, or elimination of personnel, facilities, or courses of instruction; (b) rearrangement of budgets, cost centers, funding sources; and (c) changes which by implication could impact other campuses within the Montana University System and community colleges. Board policy 303.1 indicates the curricular proposals in this category:

___ **1. Change names of degrees (e.g. from B.A. to B.F.A.)**

___ **2. Implement a new minor or certificate where there is no major or no option in a major;**

X **3. Establish new degrees and add majors to existing degrees; and**

___ **4. Any other changes in governance and organization as described in Board of Regents' Policy 218, such as formation, elimination or consolidation of a college, division, school, department, institute, bureau, center, station, laboratory, or similar unit.**

Specify Request:

Montana State University requests approval to establish a Doctor of Nursing Practice (DNP) degree. This new program is congruent with the recommendation of the American Association of Colleges of Nursing (AACN) who voted in 2004 to support moving the current level of preparation necessary for advanced practice nurses (nurse practitioners, midwives, clinical nurse specialists, and certified nurse anesthetists) from the master's degree to the doctorate by the year 2015. If the DNP is approved, the nurse practitioner options at the master's level will be eliminated.

Montana Board of Regents

CURRICULUM PROPOSALS

1. Overview

The College of Nursing at Montana State University-Bozeman is seeking approval to offer a Doctor of Nursing Practice (DNP) degree. Students who have a baccalaureate degree in nursing or a master's degree in nursing will be eligible for admittance to this program. This new program is congruent with the recommendation of the American Association of Colleges of Nursing (AACN) who voted in 2004 to support moving the current level of preparation necessary for advanced practice nurses (nurse practitioners, midwives, clinical nurse specialists, and certified nurse anesthetists) from the master's degree to the doctorate by the year 2015. The College of Nursing currently offers three master's degree options, two of which are for advanced practice nurses (Family Nurse Practitioner and Family Psychiatric Mental Health Nurse Practitioner). The college is proposing to no longer offer the two nurse practitioner options at the master's level; these options will be moved to the doctoral level. The DNP degree is one of two terminal degrees currently offered by the profession of nursing with the other being the PhD. The DNP is a practice-focused degree and prepares experts in advanced clinical practice while the PhD is a research-focused degree designed to prepare nurse scientists and scholars. Currently, the College of Nursing offers no doctoral degree.

2. Provide a one paragraph description of the proposed program. Be specific about what degree, major, minor or option is sought.

The Doctor of Nursing Practice (DNP) will target students who have a baccalaureate degree in nursing or a master's degree in nursing. The DNP degree is one of two terminal degrees currently offered by the profession of nursing with the other being the PhD. The DNP is a practice-focused degree and prepares experts in advanced clinical practice while the PhD is a research-focused degree designed to prepare nurse scientists and scholars. Currently, the College of Nursing offers no doctoral degree.

3. Need

A. To what specific need is the institution responding in developing the proposed program?

Besides AACN's decision in 2004 to adopt the goal that preparation for advanced practice nurses should occur at the doctoral level, other societal, scientific, and professional developments are stimulating this shift in graduate nursing education. The changing demands of the nation's complex healthcare environment require the highest level of scientific knowledge and practice expertise to assure quality patient outcomes. The Institute of Medicine, the Joint Commission for the Accreditation of Health Care Organizations, and the Robert Wood Johnson Foundation have called for reconceptualizing educational programs that prepare today's health professionals, including nurses. Some of the many factors building momentum for change in nursing education at the graduate level include: the rapid expansion of knowledge underlying practice; the complexity of patients' illnesses and the high level of skill that is required of caregivers; national concerns about the quality of care and patient safety; shortages of nursing personnel that demand a higher level of preparation for leaders who can design and assess care; and shortages of doctorally-prepared nursing faculty. In a 2005 report titled *Advancing the Nation's Health Needs: NIH Research Training Programs*, the National Research Council called for the nursing profession to develop a non-research clinical doctorate to prepare expert practitioners who can also serve as clinical faculty. AACN's work to advance the DNP is consistent with these calls to action and societal changes. Nursing is moving in the direction of other

health professions as it transitions to the DNP. Medicine (MD), Dentistry (DDS), Pharmacy (PharmD), Psychology (PsyD), Physical Therapy (DPT), and Audiology (AudD) all offer practice doctorates.

B. How will students and any other affected constituencies be served by the proposed program?

The DNP program will meet the needs of baccalaureate and master's prepared nurses who seek to earn a degree on par with the recommendation of the national organization. They will not have to leave the state to earn the degree that is becoming the standard for advanced preparation of nurses. There are currently 37 states plus the District of Columbia that have schools that offer the DNP degree (or will beginning fall 2012) including six states surrounding Montana (CO, ND, OR, SD, UT, and WA). One hundred fifty-three DNP programs are currently enrolling students at schools of nursing nationwide, and an additional 160 DNP programs are in the planning stage.

Consumers will be well served by graduates of this program in that the DNP prepared nurse is an excellent fit for a rural state such as Montana. With approval of this degree, MSU-Bozeman will begin preparing and graduating nurses with a clinical doctorate. Simultaneously, Montana's citizens will begin to receive care from highly skilled doctorally prepared professional nurses who can provide quality, primary care for children, adults, and the elderly. Additionally nurses with a DNP degree will have skills in the areas of organization and systems leadership, clinical scholarship, information systems/technology and patient care technology, health care policy, interprofessional collaboration, clinical prevention and population health. These additional competencies will result in highly educated practitioners who will not only provide expert direct primary care, but also will be leaders in the improvement and transformation of health care – both of which are desperately needed in Montana's rural remote areas.

C. What is the anticipated demand for the program? How was this determined?

The College of Nursing posted an online interest survey beginning in June 2011 and also randomly selected 200 nurses to receive a postcard inviting them to complete the survey. To date, 54 nurses have responded with 47 (87%) stating they are interested in pursuing a Doctor of Nursing Practice degree. Thirty of those 47 (63.8%) responded they would like to start within 1-2 years and 11 (23.4%) within 3-4 years. Twenty-three respondents voluntarily revealed their name and address to facilitate ongoing communication; 18 of those reside in Montana. Anecdotally, graduate program staff in the College have begun informing prospective students who contact the College with interest about the nurse practitioner options that the College is planning (if approved) to begin offering a DNP degree and no longer a master's nurse practitioner option. Those inquiring are generally positive and rarely express lack of interest.

4. Institutional and System Fit

A. What is the connection between the proposed program and existing programs at the institution?

The baccalaureate nursing program and master's nursing options currently offered by the MSU-Bozeman College of Nursing will provide a foundation for students entering the DNP program. As a result of the implementation of the DNP program, the two master's degree nurse practitioner options (Family Nurse Practitioner and Family Psychiatric Mental Health Nurse Practitioner) will no longer be offered by the College. The College of Nursing will follow the mandate of the American Association of

Montana Board of Regents
CURRICULUM PROPOSALS

Colleges of Nursing and prepare advanced practice nurses at the doctoral level by offering the DNP degree. The Clinical Nurse Leader master's degree option will continue to be offered as it is now.

B. Will approval of the proposed program require changes to any existing programs at the institution? If so, please describe.

The two nurse practitioner options offered in the College of Nursing will no longer be offered at the master's level. The preparation to become an advanced practice nurse will occur at the doctoral level and will lead to the DNP degree.

C. Describe what differentiates this program from other, closely related programs at the institution (if appropriate).

There are no other graduate nursing programs offered at any of the MSU campuses (Northern, Billings, or Great Falls). This will be the first doctoral degree in nursing offered in the state of Montana. The DNP curricula will expand the current scope of practice of advanced practice nurses (e.g. nurse practitioners) that are currently educated in the College. Students currently enrolled in the master's degree nurse practitioner options will be allowed to complete their course of study.

D. How does the proposed program serve to advance the strategic goals of the institution?

The Vision of MSU is: "*Montana State University will be the university of choice for those seeking a student-centered learning environment distinguished by innovation and discovery in a Rocky Mountain setting.*" The proposed DNP program is student centered in that didactic courses will be delivered using distance technologies (e.g. Internet; videoconferencing) so students can remain in their home locale. Most students will be able to complete the clinical component of the curriculum in or near their hometowns depending on the availability of clinical resources and preceptors.

The program supports the Mission of MSU *"To serve the people and communities of Montana by sharing our expertise and collaborating with others to improve the lives and prosperity of Montanans."* The College of Nursing has graduated over 150 advanced practice nurses since the mid-1990's. The vast majority of these graduates have remained in the state to practice, many serving in rural remote areas that have little or no physician coverage. These new doctorally prepared advanced practice nurses will be even better prepared to meet the primary health care needs of the citizens of Montana.

The DNP program will advance the following "MSU Five Year Outlook – FY 09 to 14" goals:

Curriculum:

- *Goal: "MSU will have graduate programs that are nationally recognized for research and teaching"* - The DNP program will enhance the College's national reputation as a leader in nursing. As a result of a rigorous, quality curriculum, and excellent teaching, graduates will be prepared to be expert clinicians, to be leaders at the systems level, and to use evidence to make a difference in practice and patient outcomes.

- *Goal: "There will be increased opportunities for interdisciplinary courses and programs and encouragement of team teaching across all disciplinary boundaries"* - The non-clinical courses that focus, for example, on systems leadership, information

management, and health policy lend themselves to interdisciplinary courses, collaboration, and team teaching. Efforts will be made to form partnerships with non-nurse faculty when teaching the DNP students.

Looking at the broader context, this program supports the MUS Strategic Plan - Goal 2, Objective 2.1.2 *"Increase degrees and certificates awarded in high-demand occupational fields."* Advanced practice nurses remain in high demand and will be even more so as the proportion of our population who are aged increases. That population is plagued with chronic illnesses and benefits greatly from the expertise offered by advanced practice nurses. The chronic illnesses that are associated with aging tend to be complicated. These complicated symptoms and the complex treatments that are necessary require the advanced expertise that a nurse who has earned a DNP can provide.

E. Describe the relationship between the proposed program and any similar programs within the Montana University System. In cases of substantial duplication, explain the need for the proposed program at an additional institution. Describe any efforts that were made to collaborate with these similar programs; and if no efforts were made, explain why. If articulation or transfer agreements have been developed for the substantially duplicated programs, please include the agreement(s) as part of the documentation.

The MSU-Bozeman College of Nursing offers the only graduate nursing education program in Montana, thus there is no relationship or duplication with other programs. Of the fifteen Western Interstate Commission for Higher Education (WICHE) schools, eleven offer DNP programs which again, speaks to the fact that the DNP is the new standard in advanced practice nursing education. The MSU program will most likely not draw students from those out-of-state programs in that the size of nursing programs is limited by clinical resources. The didactic portion of the MSU program will be on-line, but clinical experiences are generally completed in the state or in close proximity because of the need for clinical supervision by MSU faculty. Anecdotally, deans of other DNP programs in the area have shared with Dean Melland of the College of Nursing that applications are high and there are generally more applicants than there are slots in most if not all programs.

5. Program Details

A. Provide a detailed description of the proposed curriculum. Where possible, present the information in the form intended to appear in the catalog or other publications. NOTE: In the case of two-year degree programs and certificates of applied science, the curriculum should include enough detail to determine if the characteristics set out in Regents' Policy 301.12 have been met.

The DNP curricula will build on the curricula that nurses who have a baccalaureate or master's degree in nursing have completed. Because students will enter the program with different degrees (post-baccalaureate or post-master's) and experiences, the curriculum will be somewhat individualized based on courses completed prior to entering the DNP program, area of specialization, and previous clinical learning experiences. Regardless of the entry point, the DNP curriculum is designed with the requirement that all students attain the same DNP end-of-program competencies.

The curriculum for the DNP program is consistent with the AACN *Essentials of Doctoral Education for Advanced Nursing Practice*. Those essentials recommend that DNP curricula include the following content: 1) Scientific underpinnings for practice; 2) Organizational and systems leadership for quality improvement and systems thinking; 3) Clinical scholarship and analytical methods for evidence-based

practice; 4) Information systems/technology and patient care technology for the improvement and transformation of health care; 5) Health care policy for advocacy in health care; 6) Interprofessional collaboration for improving patient and population health outcomes; 7) Clinical prevention and population health for improving the nation's health; 8) Advanced nursing practice; and 9) Specialty focused competencies.

Education of the DNP is distinguished by completion of a project that demonstrates synthesis of the student's work and lays the groundwork for future scholarship. The curriculum will require students to produce an academic product that links the use of evidence to improve either practice or patient outcomes. This final DNP project will be defended by the student and reviewed and evaluated by an academic committee.

The proposed curriculum builds on the current Family Nurse Practitioner (FNP) and Family Psychiatric Mental Health Nurse Practitioner (FPMHNP) curricula. The curriculum for the DNP degree will require 79 credits versus 56-62 for the current nurse practitioner option master's degree. Completion of the DNP degree will take three years of full-time study or longer if the students chooses a part-time approach. The 79 required credits will encompass both didactic and clinical requirements. The following table includes DNP courses, credits, and the AACN curriculum essential that each course fulfills.

DOCTOR OF NURSING PRACTICE COURSES	CREDITS	AACN CURRCULUM ESSENTIAL
Advanced Health Assessment (*Core course)	3	I
Advanced Pathophysiology (*Core course)	4	I
Pharmacology (*Core course)	2	I
Advanced Pharmacology	4	I
Legal and Ethical Issues In Health Care (*Core course)	3	V
Evidence Based Practice I (*Core course)	4	III, IV
Evidence Based Practice II	3	III, IV
Differential Diagnosis	2	I
Vulnerability and Health Care In Diverse Communities	3	V
Advanced Practice Nursing Roles and Leadership	2	II, V, VI
Translational Research Methods and Design	3	III
DNP Scholarly Project Seminar	2	VII

Montana Board of Regents
CURRICULUM PROPOSALS

DNP Scholarly Project	6	VII
Organizational Systems, Economics & Change	4	II,VI
Health Care Informatics	3	IV
Program Planning, Evaluation, Outcomes, & Quality Improvement	3	III
Global Health	2	VI
FNP: Primary Care I – IV FPMHNP: Family Mental Health Nursing I – IV	26	VIII
Total DNP credits	**79**	

* These courses would also be taught in the Clinical Nurse Leader master's option.

The courses that DNP students enroll in will continue to be offered in much the same manner as the current nurse practitioner courses. The didactic courses will be offered using distance technology as is the current practice for all didactic courses offered in the Graduate Program. In order to meet course/clinical objectives and AACN standards for DNP curricula, students must complete 1,000 hours of precepted clinical learning experiences as opposed to the 500 hours required of master's degree nurse practitioner students. Students will often complete these experiences in or near their home locale depending on availability of clinical resources and clinical preceptors. Students who have already earned a master's degree as an advanced practice nurse (nurse practitioner) will receive some credit from their master's clinical hours towards the required 1,000 minimum practice hours required in the DNP as well as theory credits from their master's program.

B. Describe the planned implementation of the proposed program, including estimates of numbers of students at each stage.

If the program is approved, applications will be reviewed and admission decisions made for the DNP program in the spring of 2013 with students beginning studies in the fall semester 2013. In the past five years, the number of advanced practice (nurse practitioner) applicants has increased steadily from 37 applicants for admission in fall 2007 to 67 applicants for the fall 2011 admission; actual admission numbers have ranged from 20 – 30 per year, with that number being limited by the number of faculty and clinical capacity. Considering the interest survey and calls received from prospective students inquiring if the College is going to start a DNP program, it is reasonable to expect that the number of applicants will remain steady or continue to increase. It is anticipated that some DNP students will progress through the curriculum in three years and will graduate in the spring or summer of 2016. It is also anticipated that some students will select to progress on a part-time basis most likely because of additional time demands related to work or family and will graduate in spring of AY 2017-2018.

Montana Board of Regents
CURRICULUM PROPOSALS

6. Resources

A. Will additional faculty resources be required to implement this program? If yes, please describe the need and indicate the plan for meeting this need.

At the present time, there is a full-time Dean, a full-time Associate Dean for Research and Graduate Education in Bozeman, and a full-time Campus Director (department head) on each of the MSU College of Nursing campuses (Bozeman, Billings, Great Falls, and Missoula/Kalispell). The Associate Dean provides administrative oversight of the graduate program and will continue to do so with the implementation of the DNP program. The faculty are committed to graduate education in the College and to the development of the DNP program. Forty-five of the 100 faculty in the College had some direct involvement with the education of graduate students (e.g. teaching classes, thesis advisement, admissions review) during the 2010-2011 academic year. Non-nurse faculty teach support courses such as pharmacology.

With the introduction of the DNP program, it will be necessary to recruit additional faculty who have the knowledge, skills, and abilities needed to teach the DNP students. As previously stated, there will be an additional 17-23 credits in the DNP curriculum required beyond the current nurse practitioner master's curriculum. We estimate the need for approximately 1.5 additional full-time equivalent (FTE), predominately tenure track, faculty. Many of the faculty in the College currently teach on a part-time basis, especially the nurse practitioner clinical faculty. It is anticipated that some of these faculty may choose to increase their workload to teach the DNP students.

B. Are other, additional resources required to ensure the success of the proposed program? If yes, please describe the need and indicate the plan for meeting this need.

Since the DNP program will supplant rather than supplement the existing nurse practitioner options within the graduate program, the additional cost to deliver the DNP includes 17-23 more credits (credit variation due to differences in the different nurse practitioner specialty options), or a third year of instruction beyond the current master's. **The total estimated cost to deliver those additional credits (direct instructional costs only) is estimated to be approximately $132,506 beginning AY 2015-16 when the DNP students register for the additional year of study not required of master's prepared nurse practitioner students.** This figure is based on direct instructional costs of $98,153 (using an average tenure track salary within the College of $65,435 x 1.5 FTE), plus $34,353 in benefits (using a 35% estimated benefit rate).

On the revenue side, additional tuition dollars from student FTE's will be generated. The College admitted 28 nurse practitioner students in spring 2011 and 23 in spring 2010. If those numbers persist, or even drop slightly due to the offering of a new program, the tuition dollars generated would offset the additional program costs. Using the 2011/2012 MSU graduate resident tuition rates of $6,092.40 ($3,046.20/semester) and a net tuition yield of 95% (calculated for the College of Nursing, Fall 2011, based on tuition waivers provided), the following additional tuition dollars would be generated during the additional third year of the program:

Number of Students	Additional Tuition Dollars Generated in 3rd Year of Program
25	$144,695

Montana Board of Regents
CURRICULUM PROPOSALS

30	$173,633
35	$202,572

As we move forward with this program, **we are requesting an additional $100,000 be added to the College base dollars beginning in the 2015-16 academic year to support the additional faculty salaries needed for this program.** We believe this is justified based on the projected additional tuition revenue as shown above.

7. Assessment

How will the success of the program be measured?

The DNP degree will be evaluated using the same criteria as all other academic programs in the College. The College has a Master Evaluation Plan (see Appendix A) which is formatted according to the four standards that must be met for ongoing national accreditation by the Commission on Collegiate Nursing Education (CCNE), the accreditation arm of AACN. The Evaluation Plan provides an infrastructure for identifying what data are to be collected, where to obtain the data, the responsible group/person for analyzing the data, a timeframe for data analysis, and the feedback loop to assure that data are used to make programmatic changes, as needed, or not – based on the evaluation process.

CCNE began accrediting DNP programs during the 2008-2009 academic year and has currently accredited 80+ DNP programs. Nursing programs are required to notify CCNE of any "substantive change" which includes a new degree offering. Notification must be submitted "no earlier than 90 days prior to implementation or occurrence of the change, but no later than 90 days after implementation or occurrence of the change" (CCNE; 2009; *Procedures for Accreditation of Baccalaureate and Graduate Degree Programs*). Thus, if approved, the College will notify CCNE of this proposal in summer 2013. The College will seek CCNE accreditation of its DNP program no earlier than one year after students first enroll, per CCNE policy, thus not before fall 2014.

8. Process Leading to Submission

Describe the process of developing and approving the proposed program. Indicate, where appropriate, involvement by faculty, students, community members, potential employers, accrediting agencies, etc.

The development and offering of the DNP degree has been discussed extensively for several years in the College of Nursing among faculty and administrators at retreats, college meetings, and informal discussions. The College of Nursing 2005-2010 strategic plan states:

Strategic Direction No. 3: Offer baccalaureate and graduate curricula that are consistent with national trends in professional nursing education.

3.2. Graduate education: Increase opportunity, flexibility and innovation with quality graduate education that may include:

iii. Converting existing APRN options from MN to DNP.

The Graduate Academic Affairs Committee (GAAC) which includes faculty representation from each of the College campuses, the Associate Dean for Research and Graduate Education (non-voting), and student representation (non-voting) was actively involved in developing the curriculum for the DNP during both the 2009-2010 and 2010-2011 academic years. During the 2009-2010 academic year, the Associate Dean for Research and Graduate Education charged four task forces of faculty to develop a draft DNP curriculum

Montana Board of Regents
CURRICULUM PROPOSALS

based on the AACN *Essentials of Doctoral Education for Advanced Nursing Practice*. These task forces submitted curricular drafts to GAAC; these draft curricula provided a basis for further development of a curriculum that represents multiple faculty viewpoints and opinions and is consistent with national standards. Faculty have attended national conferences where the DNP was discussed and brought back recommendations to the faculty. The Dean of Graduate Education at MSU has been consulted and is supportive of this program based on the national recommendations and the needs in the state.

Board of Nursing approval is not required for this proposal as they do not regulate graduate education. The Executive Director of the Board of Nursing has been informed of the proposal to initiate a DNP program as a courtesy. This new program may require minor changes in the wording in the Board of Nursing Administrative Rules regarding licensure of advanced practice nurses. The Executive Director recommends the Dean of the College attend the Advanced Practice subcommittee of the Board of Nursing to discuss the need for rules changes. These changes will not need to be codified until the first class of DNP students graduate, which according to the proposed schedule, would be spring of 2016.

August 6, 2012

ITEM 156-2002- C0812
Latin American and Latino Studies Option

THAT

The Board of Regents of Higher Education authorizes Montana State University-Bozeman to establish a Latin American and Latino Studies Option

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EXPLANATION

Montana State University requests approval to establish a Latin American and Latino Studies (LALS) option within the Department of Modern Languages & Literatures. This new program will serve the interdisciplinary needs of a growing number of students who want to have a more holistic understanding of the region. Options such as LALS complement the knowledge of culture and language with courses from other disciplines that address the region from a different and focused perspective.

The LALS major option will couple the minor's multidisciplinary impulses to a wider set of globally-oriented and multicultural courses. The LALS minor will continue to exist for it serves a large number of students from majors such as Engineering, Film, and Architecture who have little flexibility in their schedules. The LALS major option aims to provide students with a multidisciplinary, international and multicultural program of study to better understand Latin American and Latino societies and cultures. The Latino Studies component of the curriculum in the new option is designed to educate students about the fastest growing minority group in the United States, including states like Montana. The LALS option will continue to enlist existing faculty resources and course offerings in the Department of Modern Languages & Literatures and the Department of Sociology & Anthropology.

The proposed option and curriculum responds to the ongoing desire for a diverse offering of multidisciplinary, international, and multicultural courses and the development of critical approaches for engaging the changing world.

ATTACHMENTS

Level II Request Form
Curriculum Proposal

Montana Board of Regents

LEVEL II REQUEST FORM

Item Number: **156-2002-C0812** Meeting Date: **August 6, 2012**

Institution: **Montana State University – Bozeman** CIP Code: **05.01107**

Program Title: **Latin American and Latino Studies Option**

Level II proposals require approval by the Board of Regents.

Level II action requested ***(place an X for all that apply and submit with completed Curriculum Proposals Form):***

Level II proposals entail substantive additions to, alterations in, or termination of programs, structures, or administrative or academic entities typically characterized by the (a) addition, reassignment, or elimination of personnel, facilities, or courses of instruction; (b) rearrangement of budgets, cost centers, funding sources; and (c) changes which by implication could impact other campuses within the Montana University System and community colleges. Board policy 303.1 indicates the curricular proposals in this category:

___ **1. Change names of degrees (e.g. from B.A. to B.F.A.)**

___ **2. Implement a new minor or certificate where there is no major or no option in a major;**

X **3. Establish new degrees and add majors to existing degrees; and**

___ **4. Any other changes in governance and organization as described in Board of Regents' Policy 218, such as formation, elimination or consolidation of a college, division, school, department, institute, bureau, center, station, laboratory, or similar unit.**

Specify Request:

Montana State University requests approval to establish a Latin American and Latino Studies (LALS) option within the Department of Modern Languages & Literatures. This new program will serve the interdisciplinary needs of a growing number of students who want to have a more holistic understanding of the region. Options such as LALS complement the knowledge of culture and language with courses from other disciplines that address the region from a different and focused perspective.

Montana Board of Regents

CURRICULUM PROPOSALS

1. Overview

The proposed Latin American and Latino Studies (LALS) option differs considerably from the Hispanic Studies (formerly known as Spanish) option. Hispanic Studies focuses on language proficiency and offers a broad survey of the cultures and societies of Spain and Latin America. The great majority of upper-division content courses are taught in Spanish and students need to have advanced language skills to take these classes. Hispanic Studies is thus a more traditional track. It is the equivalent of a B.A. in English in that the "Writing" option is our language acquisition component and the "Literature" option is our content courses. In recent decades, universities across the country and the rest of the world began offering majors like LALS (similar to the creation of American Studies) to serve the interdisciplinary needs of a growing number of students who wanted to have a more holistic understanding of the region. Options such as LALS complement the knowledge of culture and language with courses from other disciplines that address the region from a different and focused perspective. As a result, students in these options take most of their courses in English.

The LALS major option will couple the minor's multidisciplinary impulses to a wider set of globally-oriented and multicultural courses. The LALS minor will continue to exist for it serves a large number of students from majors such as Engineering, Film, and Architecture who have little flexibility in their schedules. The LALS major option aims to provide students with a multidisciplinary, international and multicultural program of study to better understand Latin American and Latino societies and cultures. The Latino Studies component of the curriculum in the new option is designed to educate students about the fastest growing minority group in the United States, including states like Montana. The LALS option will continue to enlist existing faculty resources and course offerings in the Department of Modern Languages & Literatures and the Department of Sociology & Anthropology.

2. Provide a one paragraph description of the proposed program. Be specific about what degree, major, minor or option is sought.

Montana State University is proposing to expand their existing Latin American and Latino Studies minor into a Latin American and Latino Studies option within the Department of Modern Languages & Literatures. No additional resources will be needed to implement the program. The department grants a "Modern Languages and Literatures" degree with the choice of six major options: Hispanic Studies, French and Francophone Studies, and German Studies, Spanish K-12 Teaching, French K-12 Teaching, German K-12 Teaching. In addition, the Department of Modern Languages and Literatures currently offers six minors: Hispanic Studies, Latin American and Latino Studies, French, German, Japan Studies, Chinese Studies.

3. Need

A. To what specific need is the institution responding in developing the proposed program?

The proposed option and curriculum responds to the ongoing desire for a diverse offering of multidisciplinary, international, and multicultural courses and the development of critical approaches for engaging the changing world. Learning about Latin America through the lens of different fields such as Sociology, Spanish, or History enriches the students understanding of the region. In addition, students can participate in service-learning opportunities suited to their individual disciplinary interests (Engineering, Education, Counseling, Health Professions, etc.) through opportunities already in place in the major or by proposing a new one.

Student response to the LALS minor has been strong. Informal data from advising students highlights the diversity of courses available and the contemporary perspectives on Latin American and Latino communities as important attractions to the minor. Spanish language development and the encouragement for travel in Latin America also rate high in student complements of the current minor. As a major option, students will be able to explore this program of study in much greater depth, and be better prepared to address the various changes impacting our own country while developing a more nuanced awareness of the political, economic, and cultural transformations affecting and linking us to our Latin American neighbors as well.

B. How will students and any other affected constituencies be served by the proposed program?

The Latin American and Latino Studies major will provide students with an in-depth program of study relevant to the contemporary transformations in the US and internationally. With its multidisciplinary focus and emphasis on developing Spanish cultural and linguistic skills, the LALS major will offer an important forum for training the next generation of student leaders as well. The program builds on current extracurricular activities sponsored through MSU to support leadership skills as well as fostering a sense of civic duty within students. Students will be encouraged to participate in the Tías y Tíos ("Aunts and Uncles") tutoring and Sunday activities that support local Latino youth. In addition, we have partnered with MT-Tech on the Engineers without Borders project in El Salvador. For the next five years, our students will be part of the project that has been assigned to MT-Tech in a small town an hour outside San Salvador. There are also ongoing opportunities to teach Spanish in the Bozeman Public schools. In conjunction with study abroad opportunities throughout Latin America and the continuing importance in understanding Latino communities throughout the US, the LALS option will continue to be attractive to students with a diverse set of long-term professional and personal goals.

C. What is the anticipated demand for the program? How was this determined?

The LALS option will graduate about 15 to 20 students per year. The anticipated demand for the program is based on the current number of students enrolled in the minor as well as a comprehensive questionnaire submitted in Latin American and Latino themed courses to determine demand. Based on advisors' collection of data, there are approximately 100 declared minors or students intending to declare a minor in Latin American and Latino Studies. These students self-identify as being much more interested in Latin American and Latino issues than in our traditionally bound language and literature option. The questionnaires indicate that students from a wide range of fields are already seeking out LALS courses and that they do so in order to enhance their career futures. More than half of those interested in or intending to declare the minor are pursuing programs of study outside the humanities and social sciences; the most sizeable groups are majors in engineering and health/premedical programs. These figures indicate that students in non-humanities majors consider this area of cultural, historical, and linguistic literacy vital to their marketability and professional success in those fields. These students are more interested in acquiring a multidisciplinary literacy rather than a single discipline's approach to the area. Consistently heavy enrollments in Latin-America themed courses and robust student interest in the LALS non-teaching minor signal the success of this program and justify the creation of an LALS major.

Montana Board of Regents
CURRICULUM PROPOSALS

4. Institutional and System Fit

A. What is the connection between the proposed program and existing programs at the institution?

The LALS option builds on the LALS minor (which will stay in place) and represents a restructuring of disparate, but related, resources in the Modern Languages & Literatures and Sociology & Anthropology departments. Considering the growing Latino population in the state of Montana, and in Gallatin County in particular, the LALS Major will be a superb complement to research and teaching in a number of other departments such as Nursing, History, Health, Education, and Political Science. Students from these disciplines are already taking our Latin American/Latino-themed courses.

B. Will approval of the proposed program require changes to any existing programs at the institution? If so, please describe.

No, approval of the proposed program will not require changes to any existing programs at the institution.

C. Describe what differentiates this program from other, closely related programs at the institution (if appropriate).

The LALS option differs considerably from the Hispanic Studies option. It is the same difference that exists between English (language and literature) and American Studies (interdisciplinary). Hispanic Studies focuses on language proficiency and a survey of cultures and societies of Spain and Latin America mainly through the study of literature. The great majority of upper-division content courses are taught in Spanish and students need to have advanced language skills to take these classes. Hispanic Studies is thus a more traditional track.

The Latin American and Latino Studies option presents a much more comprehensive and in-depth program of study than the current minor. The LALS option also provides a broader multidisciplinary approach to Latin American and Latino societies and cultures than the Hispanic Language and Literature option can offer. In addition, the Latino Studies component of the curriculum in the new option is designed to educate students about the fastest growing minority group in the United States, including states like Montana. Most courses in LALS are taken in English.

D. How does the proposed program serve to advance the strategic goals of the institution?

The Latin American and Latino Studies option fits perfectly within Montana State University's institutional goals. More specifically, it aligns with the President's recent commitment to "a significant expansion of interdisciplinary programs at MSU," her "MSU Moving Mountains." President Cruzado describes Moving Mountains as "an initiative that will challenge faculty to develop new research and creative projects that will reinforce our success rate for competitive external funds in interdisciplinary initiatives. The vibrant programs that can result from this effort will significantly enhance our recruitment and retention of students and faculty interested in comprehensive topics involving multiple disciplines linked through integrated approaches. Such a project will also capitalize on opportunities for collaboration between all our campuses and with universities throughout the entire state." We envision securing external funds through grants that emphasize interdisciplinary projects. For example, the Andrew W. Mellon Foundation through the American Council of Learned Societies ' Collaborative Research Fellowships supports collaborative research in the humanities and social sciences. One such project would focus, for instance,

on Latino immigrants in Bozeman from a cultural, community health, and sociological perspective. Another possible source of funding is a USAID federal grant. An example of such grant is the Mexican Partnership Program, in which faculty and students from departments such as MLL and Engineering would partner with Mexican NGOs to engage civil society in promoting clean energy technologies and reduce deforestation.

In addition, the LALS option will serve to advance the goals put forth in the current draft of the new strategic plan for Montana State University, particularly in the areas of Integration, Learning, and Engagement. Students in the LALS option will have the incredible opportunity of working with professors from different disciplines with the added bonus of knowing that these professors are themselves working together. The interdisciplinary nature of LALS provides students with an edge in their future careers and job placement. In today's highly competitive job market, an employer who, for instance, needs an engineer for its global company, everything else being equal, the employer is likely to hire the candidate who is able to understand the needs and context of other countries. Service learning is a key component of this program and aligns closely with MSU's new designation as a Carnegie Outreach Institution. We plan to continue developing service learning opportunities which will make the LALS program unique in the region by fully integrating student learning with the needs of the community. The LALS option also aims to build on the land grant mission by disseminating knowledge about Latinos in Montana and throughout the US to Montana citizens and by working to pinpoint areas of special need for the growing numbers of Latinos in the state. Such needs may include Spanish-English translation work at educational, medical, and law institutions throughout Gallatin County.

E. Describe the relationship between the proposed program and any similar programs within the Montana University System. In cases of substantial duplication, explain the need for the proposed program at an additional institution. Describe any efforts that were made to collaborate with these similar programs; and if no efforts were made, explain why. If articulation or transfer agreements have been developed for the substantially duplicated programs, please include the agreement(s) as part of the documentation.

The Montana University system has no similar option. Thus, our proposed transformation of the minor will create the first Latin American and Latino Studies program in the state. The University of Montana, Missoula, has a minor in Latin American studies but it does not include a specific institutional focus on Latino issues. Professor Linda Gillison, Chair of the Department of Modern and Classical Languages and Literatures at UM supports our initiative to create an LALS major option at MSU.

5. Program Details

A. Provide a detailed description of the proposed curriculum. Where possible, present the information in the form intended to appear in the catalog or other publications. NOTE: In the case of two-year degree programs and certificates of applied science, the curriculum should include enough detail to determine if the characteristics set out in Regents' Policy 301.12 have been met.

Montana Board of Regents

CURRICULUM PROPOSALS

Latin American and Latino Studies Curriculum Option

CLASSES	SCHEDULE	CREDITS
Foundation Courses HSTR 130D: Latin American History (4 cr.) ML 100: Introduction to World Cultures (3 cr.)	 Fall Spring	**7 credits**
Language Requirement SPNS 101–220: (14 cr.) *Or equivalent acquired through CLEP exam, course work in high school, or study abroad; ML 291: Medical Spanish may be substituted for one of these courses.* SPNS 323: Adv. Grammar and Phonetics (3 cr.)	F, S, Summer Fall	**17 credits**
Area Requirements **Group 1: Latin America (12 credits)** SPNS 329: Cultures and Societies of Early Latin America SPNS 330: Cultures and Societies of Modern Latin America SPNS 332: Contemporary Latin American Lit. SPNS 361: Hispanic Texts and Cinema (Latin America) SPNS 335IH: Travel in Latin American Film and Lit (in English) SPNS 416: Spanish Culture and Revolution (Latin America) SPNS 430: Latin American Perspectives (in English) *SPNS 445: Hispanic Caribbean (in English) **Group 2: U.S. Latino History and Cultures (12 credits)** SOCI 368: Immigration and Inequality: Latinos in the U.S. SOCI 370: Sociology of Globalization SPNS 350: U.S. Latino History & Culture SPNS 351: U.S. Latino Literature *SPNS 280: U.S. Latino Text and Cinema (in English) *SPNS 280: Chicanos and the Southwest (in English) **Group 3: Spain (3 credits)** SPNS 320: Spanish Culture and Civilization SPNS 362: Hispanic Poetry *currently being proposed	 Spring Fall Spring Spring Summer Fall Fall Spring F S F S F alternating S alternating F F	**27 credits**
Research Capstone SPNS 470R: Capstone Seminar	 Fall, Spring	**3 credits**
OPTIONAL: Service Learning Component Tías y Tíos (actividades para niños) Tías y Tíos tutoring Spanish in the Public Schools Adult ESL Tutoring (Belgrade) Engineers without Borders-El Salvador		**3 credits**
Total credits required for major =	**54-57 credits**	

Montana Board of Regents
CURRICULUM PROPOSALS

B. Describe the planned implementation of the proposed program, including estimates of numbers of students at each stage.

The LALS option would be available to students beginning in Fall 2013. The initial target is for 15 to 20 major students, increasing to 25 to 30 graduates per year after the first five years the major is available.

6. Resources

A. Will additional faculty resources be required to implement this program? If yes, please describe the need and indicate the plan for meeting this need.

No additional faculty resources will be required to implement this program. The resources to initiate the program are already in place as a result of internal reallocation. Further support for the program will occur as vacant faculty lines are filled in areas relevant to this program (e.g. History).

B. Are other, additional resources required to ensure the success of the proposed program? If yes, please describe the need and indicate the plan for meeting this need.

No other additional resources are required to ensure the success of the proposed program. All of the courses required in the proposed curriculum have already been developed and are part of the regular offerings of the departments. Shifting student demand could lead to greater numbers of sections of these courses being offered, which will reduce the need for other courses within the departments. Student advising demands will increase, but we expect this to be manageable with current departmental resources. We will make do, as we have been, until such time as resources are available.

7. Assessment

How will the success of the program be measured?

Graduation numbers continue to be tracked for the Latin American Studies minor program. We will extend the tracking process for the major degree program as well. Informal assessments of students' views on courses and the major will be obtained through student advising. Such assessments will form the basis of questionnaires used to evaluate the major and minor degree programs from the student perspective. The Department is currently creating assessment guidelines being monitored by the Associate Dean of the College. We will do the same for this program. The Latin American and Latino Studies major and minor will be subject to program review as well, as part of the normal BOR process.

8. Process Leading to Submission

Describe the process of developing and approving the proposed program. Indicate, where appropriate, involvement by faculty, students, community members, potential employers, accrediting agencies, etc.

The Latin American and Latino Studies program was created in 2006 and approved by the Board of Regents as a minor in 2007. Since it was introduced, student response to the minor has been strong with approximately 100 students having declared or intending to declare the minor currently. Through informal discussions with students and more formal meetings amongst the Latin American and Latino Studies faculty on campus, we strongly feel the demand for an option exists and that it fills an important gap in the University's curriculum.

August 6, 2012

ITEM 156-2003-C0812
Minor in Materials

THAT

The Board of Regents of Higher Education authorizes Montana State University-Bozeman to establish a Minor in Materials

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EXPLANATION

MSU-Bozeman requests approval to establish a Minor in Materials for students majoring in Mechanical Engineering and other technical disciplines at Montana State University. The Minor will complement the ongoing inter-disciplinary materials science research activities in the College of Engineering, Physics, and Chemistry, providing students additional and valuable breadth to their degree.

The inter-disciplinary field of materials science and engineering has become critical to many emerging areas of advanced technology and their applications. As a result, there are needs and opportunities for engineers and scientists with education and training in materials science and engineering. Further, engineering students are increasingly interested in pursuing fields of study in which they can make a difference for which materials science and engineering can help augment their major studies and help students achieve their goals in engineering. The goal of the Minor in Materials is to provide students at MSU with such education and training that will enable them, upon graduation, to not only participate in projects or programs of an inter-disciplinary nature but also address challenging societal needs and complex technological advances.

Integrating the Minor in Materials with Mechanical Engineering is an ideal opportunity to leverage students existing design knowledge and Capstone project work with intelligent materials selection and thus adding design degrees of freedom. Modern breakthroughs are seldom achieved with new materials or mechanical design alone, but through an integrated process, for which this minor will enable our students to participate. While the program is initially developed to serve Mechanical Engineering students, it is anticipated that the minor can be expanded more generally to the College of Engineering and College of Letters and Sciences.

ATTACHMENTS

Level II Request Form
Curriculum Proposal

Montana Board of Regents

LEVEL II REQUEST FORM

Item Number: **156-2003-C0812** Meeting Date: **August 6, 2012**

Institution: **Montana State University – Bozeman** CIP Code: **14.1801**

Program Title: **Minor in Materials**

Level II proposals require approval by the Board of Regents.

Level II action requested ***(place an X for all that apply and submit with completed Curriculum Proposals Form):***

Level II proposals entail substantive additions to, alterations in, or termination of programs, structures, or administrative or academic entities typically characterized by the (a) addition, reassignment, or elimination of personnel, facilities, or courses of instruction; (b) rearrangement of budgets, cost centers, funding sources; and (c) changes which by implication could impact other campuses within the Montana University System and community colleges. Board policy 303.1 indicates the curricular proposals in this category:

___ **1. Change names of degrees (e.g. from B.A. to B.F.A.)**

X **2. Implement a new minor or certificate where there is no major or no option in a major;**

___ **3. Establish new degrees and add majors to existing degrees; and**

___ **4. Any other changes in governance and organization as described in Board of Regents' Policy 218, such as formation, elimination or consolidation of a college, division, school, department, institute, bureau, center, station, laboratory, or similar unit.**

Specify Request:

MSU-Bozeman requests approval to establish a Minor in Materials for students majoring in Mechanical Engineering and other technical disciplines at Montana State University. The Minor will complement the ongoing inter-disciplinary materials science research activities in the College of Engineering, Physics, and Chemistry, providing students additional and valuable breadth to their degree.

Montana Board of Regents

CURRICULUM PROPOSALS

1. Overview

The inter-disciplinary field of materials science and engineering has become critical to many emerging areas of advanced technology and their applications. As a result, there are needs and opportunities for engineers and scientists with education and training in materials science and engineering. Further, engineering students are increasingly interested in pursuing fields of study in which they can make a difference for which materials science and engineering can help augment their major studies and help students achieve their goals in engineering. This serves to increase student satisfaction of MSU's engineering education and ultimately increase enrollment in engineering at MSU.

2. Provide a one paragraph description of the proposed program. Be specific about what degree, major, minor or option is sought.

We propose a new Minor in Materials for students majoring in Mechanical Engineering and other technical disciplines at Montana State University. The Minor will complement the ongoing inter-disciplinary materials science research activities in the College of Engineering, Physics, and Chemistry, providing students additional and valuable breadth to their degree.

3. Need

A. To what specific need is the institution responding in developing the proposed program?

One goal of the Minor in Materials is to provide students at MSU with such education and training that will enable them, upon graduation, to not only participate in projects or programs of an inter-disciplinary nature but also address challenging societal needs and complex technological advances. Another goal is that the Minor in Materials motivate students toward graduate study in materials-related areas. Advances in materials have driven the development of human civilization and are a key factor in most modern technological progress. Material properties, material processing issues, or material costs are the limiting factors in the design or performance of almost all systems around us: computers, aircraft, automobiles, transportation infrastructure, prosthetics and other biomedical devices, to name just a few. Engineers, scientists, and managers in all technological sectors often must make material selection decisions based on a variety of considerations, including properties, performance, environmental impact, and cost. Material failures or inappropriate material selection decisions are often a factor in tragic loss of human life or financial losses for corporations.

MSU is endeavoring to become a nationally recognized energy research institute including focused efforts on wind, solar, and direct energy conversion for which skilled engineers knowledgeable in multi-functional materials and design are needed for industrial development. Current materials related inter-disciplinary research activities at MSU in ME, ChBE, EE, Physics, and Chemistry are growing rapidly; however, there are no dedicated materials science educational programs to help train undergraduate researchers and future graduate students at MSU. Integrating the Minor in Materials with Mechanical Engineering is an ideal opportunity to leverage students existing design knowledge and Capstone project work with intelligent materials selection and thus adding design degrees of freedom. Modern breakthroughs are seldom achieved with new materials or mechanical design alone, but through an integrated process, for which this minor will enable our students to participate. While the program is initially developed to serve Mechanical Engineering students, it is anticipated that the minor can be expanded more generally to the College of Engineering and College of Letters and

Sciences. Broad areas of interest in materials include:

- *Biomedical engineering*: Prosthetic devices, materials science of skin and bone
- *Chemistry and chemical engineering*: Material synthesis and processing.
- *Civil engineering*: Construction, infrastructure, and transportation materials
- *Electrical engineering*: Solid state devices.
- *Mathematics*: Modeling and computation of material structure, properties, and processes.
- *Mechanical engineering*: Selection of materials for mechanical designs
- *Physics*: Solid state devices. Learn more broadly about the properties and applications of materials.

B. How will students and any other affected constituencies be served by the proposed program?

Based on national and regional demands, extended breadth of research opportunities and funding sources in the materials sciences, most Carnegie Category 1 universities have either a dedicated Materials Science and Engineering department or have a dedicated Materials Science and Engineering major degree program within their respective college of engineering. For those universities without a discrete department, the Materials Science and Engineering program often resides within the Mechanical Engineering department, thus supporting the goals of this minor program from a national perspective.

While many MSU mechanical engineering graduates seek employment in engineering design positions in automotive, aerospace, and bio-medical fields, the incorporation of the Minor in Materials program could improve the academic preparation of undergraduates and create new opportunities for our students to excel with jobs in research and development as well as inter-disciplinary work within the basic sciences supporting STEM education goals. This in turn can also encourage our Mechanical Engineering students to pursue graduate studies throughout engineering, as well as Physics and Chemistry, such that we can facilitate new generations of students skilled in both the sciences and engineering, providing vital professional skills.

C. What is the anticipated demand for the program? How was this determined?

An interest in materials education is routinely mentioned by ME juniors and seniors looking for intern and research experience as well as students interested in graduate studies. The M&IE Department recently developed a new materials course, EMAT 350-Engineering Materials, developed as a professional elective for ME students. Student interest in the course and enrollment has consistently exceeded course enrollment limits, and in both mid-semester and Knapp evaluations, students indicate that they believe the course enhances their education such that it could very beneficial as a required ME course. The ME department has extensive research programs in functional materials/ceramics processing, aerospace structures/composites, MEMS, and fluid flows in porous structures all of which can be directly benefited by expanded materials courses thus enabling students to engineer the material in addition to the structures. Using a conservative estimate that 10% of

Montana Board of Regents
CURRICULUM PROPOSALS

Mechanical Engineering undergraduates pursue a minor, with nearly 700 undergraduates, enrollment in the Minor is expected to be strong not including participation from other majors.

The important synergy between Mechanical and Materials Engineering is also supported by the latest information from the Bureau of Labor Statistics, Occupational Outlook Handbook (2010-2011 Outlook). Even though Materials Science and Engineering is inherently inter-disciplinary across many engineering and science fields, it is specifically indicated that growth in both Materials and Mechanical Engineering disciplines were notably leveraged from emerging technologies in non-traditional materials/composites, as well as bio and nano technology. http://www.bls.gov/oco/ocos027.htm

Materials engineers are expected to have employment growth of 9 percent over the projections decade, about as fast as the average for all occupations. Growth should result from increased use of composite and other nontraditional materials developed through biotechnology and nanotechnology research. As manufacturing firms contract for their materials engineering needs, most employment growth is expected in professional, scientific, and technical services industries.

Mechanical engineers are expected to have employment growth of 6 percent over the projections decade, slower than the average for all occupations. Mechanical engineers are involved in the production of a wide range of products, and continued efforts to improve those products will create continued demand for their services. In addition, some new job opportunities will be created through the effects of emerging technologies in biotechnology, materials science, and nanotechnology. Additional opportunities outside of mechanical engineering will exist because the skills acquired through earning a degree in mechanical engineering often can be applied in other engineering specialties.

4. Institutional and System Fit

A. What is the connection between the proposed program and existing programs at the institution?
The proposed Minor is a conglomeration of Mechanical and Chemical Engineering as well as Physics and Chemistry. Currently, MSU does not have any similar program, particularly one that bridges both college and university disciplines.

B. Will approval of the proposed program require changes to any existing programs at the institution? If so, please describe.

The minor is leveraged from currently offered courses in ME, ChBE, Physics, and Chemistry such that no new courses need to be developed to start the proposed Minor program. While courses are currently in place, some courses have a prerequisite structure that is designed to limit enrollment to within the departments' student base only. Agreements with instructors and other departments will need to be formalized to offer the broadest base of materials related courses.

As the materials research activities in the M&IE Department and across campus continue to grow it is anticipated that additional materials related coursework will be offered that can further support the minor and offer additional areas of specialization in materials.

Montana Board of Regents
CURRICULUM PROPOSALS

C. Describe what differentiates this program from other, closely related programs at the institution (if appropriate).

There is no counterpart of this Materials Minor at MSU.

D. How does the proposed program serve to advance the strategic goals of the institution?

Montana State University has 6 strategic goals and the College of Engineering has 3 strategic goals as outlined below. The Minor in Materials ideally meets the goals the University and COE have put forth in discovery and innovation.

Montana State University:

1. A dynamic, committed student body comprised of high-ability, high-achieving students who thrive in a challenging academic environment.
2. Leadership in the nation in the integration of learning and the discovery of knowledge for undergraduate students.
3. Academic excellence that is characterized by world-class faculty and staff across the spectrum of the university.
4. World-changing research that enhances the student experience, advances economic prosperity in the state, and enables the nation to meet the challenges of the 21st century.
5. Integration of Montana State University into the fabric of the state and beyond.
6. Enhancement of the campus infrastructure in a manner that is sustainable, efficient and maintains the heritage and natural beauty of the academic setting

MSU College of Engineering:

1. Prepare the MSU COE community to engage effectively with the global community.
2. Build on growing college synergy and increase cross-disciplinary activities at every level of the COE community, including not only faculty research and creative activity but also the student experience.
3. Establish the college as a leader in the state and national technological community.

One of the key aspects of the Minor in Materials, as evidenced in the list of courses below, is the diverse learning environment created through several different departments and colleges across the MSU campus. This inter-disciplinary program will expose Mechanical Engineering students to the global community of different engineering and science majors through a focus on materials. The materials research community at MSU is strongly focused on renewable and energy conversion/storage, nano-technology, and biological systems such that the educational goals of this program will enable mechanical engineers to integrate with research teams across the campus that will facilitate a broader spectrum of job opportunities and potential for job satisfaction of ME graduates. This in turn fosters innovation and leadership in our future MSU educated mechanical engineers.

E. Describe the relationship between the proposed program and any similar programs within the Montana University System. In cases of substantial duplication, explain the need for the proposed program at an additional institution. Describe any efforts that were made to collaborate with these similar programs; and if no efforts were made, explain why. If articulation or transfer agreements

Montana Board of Regents
CURRICULUM PROPOSALS

have been developed for the substantially duplicated programs, please include the agreement(s) as part of the documentation.

Montana Tech currently offers B.S. and M.S. degrees in Metallurgical & Materials Engineering (M&ME) with a stronger focus on mining and extractive processes. Montana Tech also offers a Materials Science Minor (MSM). However, there are significant differences between the two minors. The minor at MT Tech requires 8 courses and a maximum of 18 credit hours. In contrast, to achieve the proposed Minor in Materials at MSU would require 11 courses and 29 credit hours (see below). In addition, of the 20 courses from which the 11 required courses are selected, fully 70% (14) are only available at MSU. Moreover, the 20 courses at MSU represent 6 different course rubrics (CHMY, ECHM, EMAT, EMEC, ETME, PHSX) compared to 3 (CHMY, EGEN, EMAT) at MT Tech. While the proposed Minor in Materials at MSU is designed for Mechanical Engineering majors (among others), M&ME students at MT Tech are not eligible for the Materials Science Minor.

The proposed Minor in Materials program at MSU provides an inter-disciplinary educational experience for undergraduates with coursework that spans multiple colleges. Further this Minor is also based on active research activities and collaborations more strongly associated with functional (energy) materials, ceramics, and composites for which MSU has a pronounced expertise that is nationally recognized.

5. Program Details

A. Provide a detailed description of the proposed curriculum. Where possible, present the information in the form intended to appear in the catalog or other publications. NOTE: In the case of two-year degree programs and certificates of applied science, the curriculum should include enough detail to determine if the characteristics set out in Regents' Policy 301.12 have been met.

Students seeking the Minor in Materials must *satisfy the core and additional course requirements, 29 credits total, as outlined below:*

Required Pre-requisite Courses: ***(credits not counted towards minor)***

Course #	Course Title
M 171Q	Calculus I
M 172Q	Calculus II
PHSX 220	General & Modern Physics I
PHSX 222	General & Modern Physics II
CHMY 141	College Chemistry I

Required Courses: ***(or equivalent courses as approved by the certifying officer)***

Course #	Course Title	Credits
EMAT 251	Materials Structures and Properties	3
EMAT 252	Material Structures and Properties Lab	1

Montana Board of Regents
CURRICULUM PROPOSALS

ETME 215	Manufacturing Processes	3
ETME 217	Manufacturing Processes Lab	1
EMAT 350	Engineering Materials	3

These courses (11 credits) represent the core fundamentals of materials science and are applicable to students in the College of Engineering in addition to Physics and Chemistry. Students pursuing a BS in Engineering or the Physical Sciences will have to take 18 additional course credits (6 courses) out of the list below to obtain a Minor in Materials which may also serve as electives in the students major. Other courses may also be approved by the certifying officer with a written request detailing the merit of the course.

Additional Courses: ***(no more than 3 courses may be taken from a single rubric)***

Course #	Course Title	Credits
CHMY 371	Quantum Chemistry – Part 1	3
CHMY 373	Thermo & Kinetics – Part 2	3
CHMY 401	Advanced Inorganic Chemistry	3
ECHM 424	Transport Analysis	3
ECHM 452	Advanced Engineering Materials	3
EMEC 444	Mechanical Behavior of Materials	3
EMEC 465	Bio-inspired Engineering	3
EMEC 467	Micro Electro Mechanical Systems	3
PHSX 441*	Solid State Physics	3
PHSX 442	Novel Materials for Physics & Eng	3
EMAT 460	Polymeric Materials	3
EMAT 463	Composite Materials	3
EMAT 552	Advanced Ceramics	3
EMAT 553	Advanced Composite Materials	3
EMAT 563	Smart Structures	3

****course pre-requisites not included in the lists above do not count towards the 18 credits***

B. Describe the planned implementation of the proposed program, including estimates of numbers of students at each stage.

While filing the *Application for Baccalaureate Degree* for the major, students pursuing the Minor in Materials will also have to submit the *Application for a Non-teaching Minor* by the deadlines set forth in the University Catalog. Dr. Sofie will serve as the Minor certifying officers for the Mechanical & Industrial Engineering Department and will certify that the M&IE students have completed the required course credits (as given in Section 4a) for the Minor in Materials.

The Minor in Materials is primarily applicable to students majoring in Mechanical Engineering, although students majoring in ChBE, EE, Physics, and Chemistry may also be interested given the breadth of courses offered in this minor. It is estimated that up to 20 students may be enrolled in the Minor shortly after its commencement based on our experience with the Aerospace and Mechatronics Minor's currently offered.

Montana Board of Regents
CURRICULUM PROPOSALS

As students enroll in the program from other COE departments as well as the College of Letters and Science, standard course equivalencies will be drafted and incorporated into the Minor to identify the curriculum path for non-ME majors.

6. Resources

A. Will additional faculty resources be required to implement this program? If yes, please describe the need and indicate the plan for meeting this need.

No new faculty resources are needed to implement the Materials Minor program. The Minor has been initially developed within the framework of the current catalogs, curricula, courses, and teaching schedules, therefore no new courses need to be developed. The College of Engineering has many faculty members who have the necessary background in the related fields to provide student advising and counseling as part of their regularly assigned advising duties.

B. Are other, additional resources required to ensure the success of the proposed program? If yes, please describe the need and indicate the plan for meeting this need.

No additional resources are required for successful implementation of the Minor as we do not need to develop any new courses. However, the participating departments must accommodate the inevitable increase in administrative overhead necessary to process the *Application for a Non-teaching Minor* paperwork when the student is ready to graduate. This additional work is modest, and occurs just once for each student at the time of graduation.

The Minor in Materials is primarily applicable to students majoring in Mechanical Engineering, although students majoring in ChBE, EE, Physics, and Chemistry may also be interested given the breadth of courses offered in this minor. It is estimated that up to 20 students may be enrolled in the Minor shortly after its commencement based on our experience with the Aerospace and Mechatronics Minor's currently offered.

7. Assessment

How will the success of the program be measured?

The M&IE Department in the College of Engineering incorporates a systematic assessment plan (http://www.montana.edu/wwwprov/assessment/assessmentplans.htm) for all of the academic programs and courses. We continually assess objectives and outcomes at the program and course levels. These assessments are mandatory for our continued national accreditation (ABET), and we must demonstrate the assessment and evaluation processes as part of the periodic accreditation review. Therefore, our current assessment plans and evaluation methods will be applied consistently to the Materials Minor.

In addition, we will provide specialized assessment based on student, employer, and alumni satisfaction towards the Minor through appropriate surveys. The M&IE Department has been doing this kind of survey for many years to assess the outcomes of the Mechanical Engineering program. Any changes in student enrollment or gradation rate will be monitored, reviewed, and the program will be revised accordingly.

Montana Board of Regents
CURRICULUM PROPOSALS

8. Process Leading to Submission

Describe the process of developing and approving the proposed program. Indicate, where appropriate, involvement by faculty, students, community members, potential employers, accrediting agencies, etc.

The present Minor in Materials proposal was presented before the Industrial Advisory Board (IAB) of the Mechanical & Industrial Engineering Department. The IAB was very supportive of the proposal and they responded strongly in favor of moving forward with the Minor. Several members indicated that the incorporation of materials curriculum would be a direct benefit for graduates seeking employment and provide a valuable component to future engineers.

August 6, 2012

ITEM 156-1003-C0812

Collaborative Ph.D. in Materials Science between The University of Montana–Missoula, Montana Tech of The University of Montana, and Montana State University–Bozeman

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THAT

In accordance with Montana University System Policy, The University of Montana-Missoula, Montana Tech of The University of Montana, and Montana State University-Bozeman seek approval from the Board of Regents of Higher Education to create a collaborative Ph.D. program in Materials Science, with the degree to be awarded by either The University of Montana-Missoula, Montana Tech of The University of Montana or Montana State University-Bozeman.

EXPLANATION

Given that materials science and materials engineering are growing in both the nation and the state and that many of the relevant technical concepts and issues require a level of understanding and experience equivalent to Ph.D. level training, the proposed program will focus on near-term industrial need and long-term research issues, both of which will directly benefit Montana industries. The curriculum will involve both physical science and engineering, and courses will be offered at The University of Montana-Missoula (UM), Montana Tech of The University of Montana (MTech), and Montana State University-Bozeman (MSU). Support of Ph.D. dissertations will come from several sources including extramural funding and internships from government sponsors, industrial partners, participating corporations, and affiliated research centers, particularly State Centers of Excellence.

This program will aid the efforts of various departments and centers at UM (e.g., Chemistry and CASANS: Center for Advanced Supramolecular and Nanoscale Systems), MTech (e.g., Metallurgical & Materials Engineering and CAMP: Center for Advanced Mineral and Metallurgical Processing) and MSU (e.g., Mechanical & Industrial Engineering and CBIN: Center for Bio-Inspired Nanomaterials). Implementation of the proposed Ph.D. program will enable students to pursue their studies within the Montana University System (MUS) and, additionally, attract qualified graduate students from other parts of the nation and the world.

ATTACHMENTS

Level II Request Form
Curriculum Proposal
Appendices
- Appendix I - Facilities and Equipment
- Appendix II - List of Participating Institutions
- Appendix III - Courses at UM, MTech and MSU
- Appendix IV - Benchmarking Study including PhD-Granting Institutions with MatSci and MS&E Programs
- Appendix V - Program Administration Plan

Letters of Support

Montana Board of Regents

LEVEL II REQUEST FORM

Item Number: **156-1003-C0812** Meeting Date: **August 6, 2012**

Institution: **UM-Missoula, MSU-Bozeman MT Tech** CIP Code: **40.1001**

Program Title: **Collaborative Ph.D. in Materials Science between The University of Montana–Missoula, Montana Tech of The University of Montana, and Montana State University–Bozeman**

Level II proposals require approval by the Board of Regents.

Level II action requested ***(place an X for all that apply and submit with completed Curriculum Proposals Form):***

Level II proposals entail substantive additions to, alterations in, or termination of programs, structures, or administrative or academic entities typically characterized by the (a) addition, reassignment, or elimination of personnel, facilities, or courses of instruction; (b) rearrangement of budgets, cost centers, funding sources; and (c) changes which by implication could impact other campuses within the Montana University System and community colleges. Board policy 303.1 indicates the curricular proposals in this category:

___ **1. Change names of degrees (e.g. from B.A. to B.F.A.)**

___ **2. Implement a new minor or certificate where there is no major or no option in a major;**

X **3. Establish new degrees and add majors to existing degrees; and**

___ **4. Any other changes in governance and organization as described in Board of Regents' Policy 218, such as formation, elimination or consolidation of a college, division, school, department, institute, bureau, center, station, laboratory, or similar unit.**

Specify Request:

The University of Montana-Missoula, Montana Tech of The University of Montana, and Montana State University-Bozeman request permission for a collaborative Ph.D. program in Materials Science. The program will involve multiple departments, faculty, and classes from the three campuses. In addition, research will be conducted using equipment and facilities on the three campuses as well as at participating institutions including government sponsors, industrial partners, supporting corporations, and affiliated research centers, particularly State Centers of Excellence. Finally, Ph.D.'s will be granted from The University of Montana-Missoula, Montana Tech of The University of Montana and Montana State University-Bozeman.

Montana Board of Regents

CURRICULUM PROPOSALS

1. Overview

The University of Montana-Missoula (UM), Montana Tech of The University of Montana (MTech), and Montana State University-Bozeman (MSU) propose to establish a Ph.D. program in Materials Science (MatSci). Materials Science and Engineering (MS&E) has its roots in natural materials, mostly minerals and some native metals and alloys; however, it now encompasses all minerals, metals, alloys, glasses, slags and ceramics, and modern materials such as polymers and composites. In general, materials science deals with the fundamental understanding of materials through their development and characterization regarding structure, properties, processing, and/or performance; whereas, materials engineering deals with how materials are prepared, fabricated and/or manufactured into a variety of useful products ranging from nanoscale communications to large-scale aerospace products (see Figure 1). The proposed Ph.D. program will integrate these two areas.

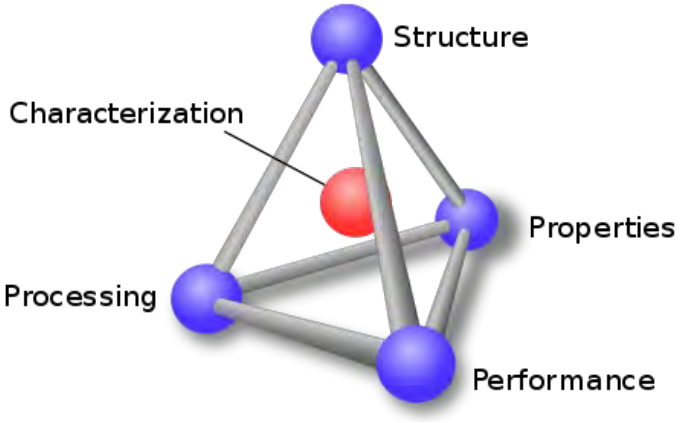


Figure 1: The Domain of Materials Science and Engineering.

It is therefore understood that materials science and materials engineering are broad and interdisciplinary fields that encompass all facets of minerals, metals, and materials. In this regard, the proposed Ph.D. program will draw upon the expertise of faculty members and research activities on the three campuses. Students will predominantly be drawn from either engineering or the basic sciences. Courses and research will be in these same areas. Major funding will be obtained from federal departments, agencies and laboratories including but not limited to DoD, DoE, NASA, NSF, NIH, INL and PNNL. Industrial partners will be an integral component of the degree, providing opportunities for applied training and venues for research. Graduates of the program are expected to find employment with research, development, and manufacturing companies in Montana, the region, and the nation. It is expected that state and local economies will also benefit from the increased entrepreneurial ventures that will result.

2. Provide a one paragraph description of the proposed program. Be specific about what degree, major, minor or option is sought.

UM, MTech and MSU propose to develop a collaborative Ph.D. program in MatSci. The program will be a collaborative effort between the three campuses, and will involve multiple departments, faculty, and classes. Research will be conducted using equipment and facilities on each of the campuses (see Appendix I)

as well as at participating institutions including government sponsors, industrial partners, supporting corporations, and affiliated research centers, particularly State Centers of Excellence (see Appendix II). UM, MTech and MSU will offer the Ph.D. degree in MatSci. The curriculum will involve both physical science and engineering. Courses will be offered at all three campuses by taking advantage of online opportunities where appropriate. All engineering courses will be offered by MTech and MSU; however, science courses will be offered on all three campuses (see Appendix III). The program will also include internships through the participating institutions listed in Appendix II. The internship projects may constitute part or all of the research upon which the Ph.D. dissertation will be based.

3. Need

A. To what specific need is the institution responding in developing the proposed program?

Nationwide, materials science and materials engineering are growing fields. The US Bureau of Labor Statistics' Occupational Outlook Handbook, 2008-09 Edition, reports that "while some materials scientists hold a degree in materials science, degrees in chemistry, physics, or electrical engineering are also common. Most research jobs in chemistry and materials science require a Master's degree or, more frequently, a Ph.D." It goes on to state that job growth "is expected to grow 9 percent over the 2006-16 decade" and that "graduates with an advanced degree, and particularly those with a Ph.D., will enjoy better opportunities." One website, http://www.indeed.com, has 4,742 postings for materials scientists and 29,565 for materials engineers. According to The US Bureau of Labor Statistics' Occupational Outlook Handbook, 2010-11 Edition, materials scientists and engineers are expected to have employment growth of 12 and 9 percent, respectively, over the next decade including two important and high-paying industries in Montana: mining and manufacturing. Although Montana lost Smurfit-Stone Container and Columbia Falls Aluminum Company during the economic downturn (http://www.bber.umt.edu/pubs/manufacturing/10manufacturing.pdf), the State essentially avoided it and recently acquired companies like SeaCast and AeroTec. At the recent APEC Meeting in Bozeman, U.S. Secretary of Commerce Gary Locke challenged Montana to increase its manufactured products to help the U.S. reach its goal of doubling exports and thereby increase annual growth rates by 15% for the next five years. It is noted that, in the past year, U.S. exports grew 17% and Montana's grew 38%. The Montana Department of Transportation forecasts that out-of-state shipments of bulk commodities and manufactured products will continue to increase. Today, in Montana, mining and manufacturing employs 7% of the population (see Figure 2) compared to 14% nationally. Consequently, it is expected that many new jobs in Montana will be in these growth areas which are important part of the research programs on the three campuses (see Appendix III).

Montana Board of Regents
CURRICULUM PROPOSALS

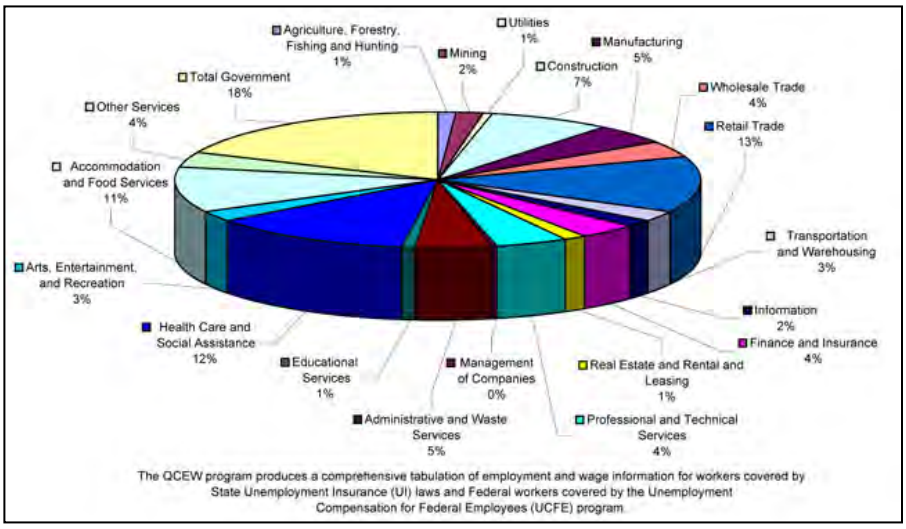


Figure 2: Montana Employment by Industry.

Montana itself is experiencing sustained growth in the highly competitive materials industry. Material scientists and engineers at existing operations (REC Silicon, AFFCO, Lattice Materials, MicroPowder Solutions LLC, Scientific Materials, Polymeric Interconnect, Applied Materials, American ChemMet and Summit Aeronautics Group), plants newly commissioned (SeaCast, Butte AeroTec and Zinc Air, Inc.), as well as research facilities (MSE Technology Applications, Inc., Resodyn , GT Solar, Montana Process Engineering, Purity Systems Inc., Federal Technology Group, UTRS-Universal Technical Resource Services, and Rivertop Renewables) must extensively apply MS&E principles to succeed in business. Many of the technical concepts and issues being dealt with by Montana industries require a level of understanding and experience equivalent to Ph.D. level training. In particular, the collaboration now required for advanced materials investigations in industrial research is becoming more common in Montana and demands more Ph.D. participation. The proposed program will focus on near-term industrial need and long-term research issues, both of which are of direct benefit to these Montana industries. It should be noted that several companies outside of Montana are also interested in participation (e.g., Boeing Materials, Exotic Metals, General Electric, Hercules, Bloom Energy, Newmont Mining Corporation, DuPont, Freeport McMoRan, Taggart Global and Imerys). See Appendix II.

No Ph.D. level MatSci or MS&E programs exist in Montana, and only two such programs are available in the contiguous states located at University of Idaho and South Dakota School of Mines and Technology (see Appendix IV). Additional programs in the Northwest/Rocky Mountain region include Washington State University and University of Washington. There are no programs in North Dakota or Wyoming. As indicated in Appendix IV, other MatSci and MS&E Ph.D. programs within close proximity to UM, MTech and MSU are located at Colorado School of Mines and The University of Utah. In this regard, the proposed Ph.D. program would eliminate a considerable educational void in Montana and the neighboring states; furthermore, it would benefit students as an alternative to the other institutions who may be interested in Materials Science. As specific benchmarks, OSU and WSU seem reasonable choices, in particular since there is no dedicated MatSci or MS&E department at either institution. The proposed consortium of UM, MTech, and MSU compares favorably against these benchmarks (see Appendix IV).

Clearly, students within the MUS who wish to pursue Ph.D. studies in this field have no alternative but to continue their education outside of the State. Implementation of the proposed Ph.D. program will enable these students to pursue their studies within the MUS and, additionally, attract qualified graduate students from other parts of the nation and the world. It is also important to note that this collaborative Ph.D. in MatSci will be broad and interdisciplinary enhancing research already conducted ranging from bio-inspired materials to natural materials (minerals and some metals and alloys) while simultaneously allowing expanded efforts in synthetic materials (other metals and alloys, ceramics, polymers, glasses, slags, and composites) on the three campuses. Furthermore, it is expected that state and local economies will benefit from increased entrepreneurial ventures; after all, as already noted, this is expected to be the next growth industry in Montana. Clearly, the proposed collaborative Ph.D. program will have a positive impact on local economies as well as The State of Montana. Furthermore, this will not only increase internship and employment opportunities for the students but will also expand the capabilities of the various State Centers of Excellence. The effect will be profound and synergistic across the board.

B. How will students and any other affected constituencies be served by the proposed program?

Over the last several years, representatives of various institutions that provide financial support for scholarship and research on the three campuses have expressed concerns about the shortage of graduate-level materials scientists and engineers, particularly at the Ph.D. level. Many of these institutions will be participants and have been mentioned above as government sponsors, industrial partners, supporting corporations, and affiliated research centers, particularly State Centers of Excellence (see Appendix II). The burgeoning growth of the materials sector within the state, and throughout the world, has intensified demand for technical personnel with advanced, in-depth knowledge of materials systems and processes. When coupled with the shortage of available graduate-level talent, the large number of impending baby-boomer retirements present a serious issue. Representatives have stated that they expect graduates of the proposed Ph.D. program will receive immediate consideration for high level positions and opportunities for rapid advancement in their respective institutions. Furthermore, most, if not all, of these institutions have moved toward interdisciplinary team models to deal with the increasing complexity of production, research and development. This program is specifically designed to ensure that the curriculum, mentors, research teams and funding will sustain its interdisciplinary nature.

As one of the core goals of the program, industrial participation will be coordinated with research and education in a manner to ensure high student retention and to expand and reinforce the relationship between industry and the three campuses. The program will afford students paid internship opportunities to establish working relationships with industrial concerns even before they are accepted as full candidates and choose formal research projects. Specific examples are the internships routinely available to students through the participating institutions, particularly the various State Centers of Excellence (see Section 5 – Program Details).

In summary, the intercampus collaborations, industrial internships and interdisciplinary nature of the proposed Ph.D. program differentiate it from most existing materials-oriented graduate programs, and certainly from those within the immediate geographical area. The program will be strongly coordinated to ultimately place highly educated and experienced graduates who will capably compete for scientific and technical management positions at all levels, including the international level.

Montana Board of Regents
CURRICULUM PROPOSALS

C. What is the anticipated demand for the program? How was this determined?

The projected demand for the proposed collaborative Ph.D. program is high. It was and continues to be driven by several constituencies on the three campuses including the administration, faculty, State Centers of Excellence, and prospective students. It was also driven by numerous institutions wanting to participate by offering internships and funding as well as research equipment and facilities. These participating institutions include government sponsors, industrial partners, and supporting corporations and will be among the first to benefit from hiring the resulting graduates. Likewise, it is expected that companies will be created and attracted to Montana. These new entrepreneurial ventures will not only enhance local and state economies, they will increase internship and employment opportunities for students and graduates at all levels offering them a means to stay in Montana.

The idea behind this proposal came from UM President Dennison in September of 2008. Ensuing meetings and e-mail discussions among faculty in the Departments of Chemistry and Physics at UM and Metallurgical & Materials Engineering at MTech resulted in the first version of the proposal being completed and then approved on both campuses in October of 2010. Faculty in the Departments of Chemistry, Physics, Mechanical & Industrial Engineering and Chemical & Biological Engineering along with Administration at MSU were then notified. A few more meetings and e-mail discussions eventually resulted in this proposed collaborative Ph.D. program among the three campuses.

While the two drafts of the proposal were being prepared, various people were asked about the program. Several students, industrial representatives, and non-doctoral faculty responded favorably saying that they would enroll immediately if funding were available. Recently, four engineering students with M.S. degrees from MTech recently completed their Ph.D. in Chemistry or Individualized Interdisciplinary Program (IIP) at UM. This underlines the need for this proposed Ph.D. program. MTech projects that as many as nine students will enroll if the program becomes available. This includes five students that are currently involved in funded research efforts and another four professionals that are currently employed in materials-oriented businesses within the region, including two faculty members wanting to obtain terminal degrees. MTech further notes that five M.S. graduates from its Metallurgical/Mineral Processing Engineering Program in the last three years left the state to pursue Ph.D. degrees. Of these, two were international and four reported they would have stayed at MTech if it had a Ph.D. program. Likewise, MSU notes that several of its M.S. students would pursue a Ph.D. in MatSci. Otherwise, these students would either pursue their Ph.D. studies outside of the State of Montana (which has been the case) or simply elect not to obtain a Ph.D. Based on the benchmarking study, at least 15 doctoral students in the proposed program across the campuses at steady-state is not unreasonable.

There are additional points worth noting. At UM, the sharp increase in undergraduate enrollment numbers in Chemistry and Physics in the last few years can be attributed to the expansion of materials-related research, including undergraduate research. At MTech, the change in name of its Metallurgical Engineering department to Metallurgical “& Materials” Engineering has helped it enrollments grow significantly as well. Furthermore, its research, including with its affiliate State Center of Excellence (CAMP), has increased exponentially over the last five years. At MSU, materials-related research has grown substantially as well. Elsewhere, for example, the MS&E program at Washington State University is claimed to be the fastest growing program at the university. Job boards routinely post over 5,000 materials science jobs, and Ph.D. level job boards show large numbers of materials scientist positions as well. As mentioned above, substantial industrial interest in graduates already exists due to the need for

replacing an aging professional workforce. These facts help illustrate that a Ph.D. program in MatSci will have positive effects on B.S. and M.S. programs. Furthermore, the facts are documented by the attached letters of support (See Appendix II).

4. Institutional and System Fit

A. What is the connection between the proposed program and existing programs at the institution?

The collaborative Ph.D. program will be anchored by the Chemistry and Physics Departments at UM, the Chemistry, General Engineering, and Metallurgical and Materials Engineering Departments at MTech, and the Chemistry, Chemical & Biological Engineering, Mechanical & Industrial Engineering, and Physics Departments at MSU. Because it is expected that faculty from other departments will become active participants as the program grows, participation will not be restricted to these departments. To this end, faculty members within other departments on the three campuses have expressed their interest and willingness to participate. These include Computer Science, Geosciences and Mathematics at UM, Environmental Engineering and Biological Sciences at MTech, and Cell and Neurobiology, Civil Engineering, and Electrical & Computer Engineering at MSU. Such broadened participation will further enhance the interdisciplinary aspect of the collaborative program. The availability of additional facilities and equipment will elevate the level of research, which in turn will attract additional research funding opportunities. The direct involvement of the students with the Centers will not only benefit the students, but also will expand the capabilities of the Centers, will have a positive impact on the economy of The State of Montana, and will affect the B.S. and M.S. programs positively as well.

B. Will approval of the proposed program require changes to any existing programs at the institution? If so, please describe.

No.

C. Describe what differentiates this program from other, closely related programs at the institution (if appropriate).

The proposed collaborative Ph.D. program in MatSci is like no other program in the state for several reasons. First, it draws from the strengths of materials-related departments on three campuses (inter-institutional) and, in doing so, becomes inherently interdisciplinary (intra-institutional). Second, it integrates industry through a strong internship program and use of their equipment and facilities. Third, neither UM nor MSU have a formal MatSci program. Fourth, MTech does have a healthy Metallurgical and Materials Engineering Department that offers B.S. and M.S. degrees but does not have a Ph.D. program. Fifth, in this regard, the proposed program will supplement the already available degrees at UM, MTech and MSU.

D. How does the proposed program serve to advance the strategic goals of the institution?

The goals of the participating institutions emphasize the following principles which emanate from the strategic plans of the three institutions as well as the BOR:

<u>UM Goals</u>

- Provide an integrated learning environment achieved through collaboration.
- Maintain an active learning environment that will attract and educate motivated and capable

students working on actual problems of interest to local industries.
- Sustain programs that enhance students, faculty and state.
- Conduct basic and applied research, technology transfer, and cultural outreach.
- Have telecommunication and distance training.

MTech Goals
- Provide a quality education that blends theory with practice.
- Attract and retain faculty with national reputations in their area of research.
- Prepare students for research and technical management careers in the natural resources and energy industries.

MSU Goals
- Increase cross-disciplinary activities at every level, including not only faculty research and creative activity but also the student experience.
- Provide leadership in the state and national technological community.

BOR Goals
- Prepare students for success through quality higher education.
- Increase responsiveness to workforce development.
- Expand research and technology transfer.

The proposed program establishes these goals as core values. It will be founded on an integrated, collaborative and interdisciplinary structure. The collaborative effort will foster an active learning environment where all participating students and faculty will interact. The collaborative effort will also be extended to industry such that applied research will be emphasized but not at the sacrifice of fundamental research. This will enhance industry-related funding opportunities for faculty and thereby help facilitate technology transfer to industry as well as dissemination of resulting knowledge to the public domain. From the outset, teleconferencing (using existing facilities) will be an integral part of the program. Additionally, costs will be minimized by taking advantage of the expertise, facilities and equipment already available at research facilities located on all campuses.

E. Describe the relationship between the proposed program and any similar programs within the Montana University System. In cases of substantial duplication, explain the need for the proposed program at an additional institution. Describe any efforts that were made to collaborate with these similar programs; and if no efforts were made, explain why. If articulation or transfer agreements have been developed for the substantially duplicated programs, please include the agreement(s) as part of the documentation.

There are no comparable Ph.D. programs within the MUS or, for that matter, within any of the State's private colleges and universities. In fact, the strength of the proposed Ph.D. program is that it is collaborative involving three campuses already doing substantial amounts of materials research.

Montana Board of Regents
CURRICULUM PROPOSALS

5. Program Details

A. Provide a detailed description of the proposed curriculum. Where possible, present the information in the form intended to appear in the catalog or other publications. NOTE: In the case of two-year degree programs and certificates of applied science, the curriculum should include enough detail to determine if the characteristics set out in Regents' Policy 301.12 have been met.

The Ph.D. degree requires that the student complete a minimum of sixty (60) semester-hour credits, which are subject to committee review and approval. Following the completion of one semester in the program and upon recommendation of the student's graduate committee, credits from an existing M.S. degree can be applied toward the Ph.D. credit requirement. The program will allow up to twenty-four (24) course semester-hour credits to be transferred. Each student will take two 3-credit courses in kinetics and thermodynamics. In addition to these two foundation courses, each student will also take a core curriculum of four 3-credit courses which reflect the core areas of Figure 1 and the interdisciplinary nature of the program. These foundation and core courses will total 18 semester-hour credits. Additional detail is provided under Program Description, on the next page.

Faculty:
At a minimum, faculty in the Chemistry and Physics Departments at UM, Chemistry, General Engineering, and Metallurgical & Materials Engineering Departments at MTech, and Chemistry, Chemical & Biological Engineering, Mechanical & Industrial Engineering, and Physics Departments at MSU will participate. These faculty may include, but are not limited to:

UM Faculty
- Xi Chu - Chemistry
- Chris Palmer - Chemistry
- Edward Rosenberg - Chemistry
- Sandy Ross - Chemistry
- Aaron Thomas - Chemistry
- David Esteves - Physics

MTech Faculty
- Doug Cameron - Chemistry
- Jerry Downey - Metallurgical & Materials Engineering
- Butch Gerbrandt - General Engineering
- Bill Gleason - Metallurgical & Materials Engineering
- David Hobbs - Chemistry
- H.H. Huang - Metallurgical & Materials Engineering
- Rajendra Kasinath - Environmental Engineering
- Michael Klem - Chemistry
- Alan Meier - Metallurgical & Materials Engineering
- Marisa Pedulla - Biological Sciences
- K.V. Sudhakar - Metallurgical & Materials Engineering
- Courtney Young - Metallurgical & Materials Engineering

Montana Board of Regents
CURRICULUM PROPOSALS

MSU Faculty

Recep Avci - Physics
Doug Cairns - Mechanical & Industrial Engineering
Rufus Cone - Physics
Trevor Douglas - Chemistry
Paul Gannon - Chemical & Biological Engineering
Yves Idzerda - Physics
Chris Jenkins - Mechanical & Industrial Engineering
Ron June - Mechanical & Industrial Engineering Department
Galina Malovichko - Physics
John Mandell - Chemical & Biological Engineering
Ahsan Mian - Mechanical & Industrial Engineering
David Miller - Mechanical & Industrial Engineering
John Neumeier - Physics
David Singel - Chemistry
Dick Smith - Physics
Stephen Sofie - Mechanical & Industrial Engineering
Robert Szilagyi - Chemistry
Rob Walker - Chemistry

Program Description:

The Ph.D. program in MatSci is designed by the student in consultation with his/her advisor to accommodate the student's interests and career objectives within the realm of materials science and/or materials engineering. The Program of Study must be approved by the student's graduate committee and the Academic Advisory Board (see Appendix V); it also must conform to all applicable UM, MTech and MSU graduate school policies and regulations.

To earn the Ph.D. degree, the student must fulfill the following program requirements:

1. Complete at least forty-two (42) semester hours of acceptable course work, which may include up to twenty-four (24) transferable graduate course credits presented for the student's M.S. degree, if approved by the graduate committee, and provided that the M.S. degree was in MatSci, MS&E, or a similar science or engineering field.
2. A minimum of nine semester hours of approved course work must be taken away from the home campus. On-line and distance-learning courses will be offered to help the student meet this requirement.
3. Obtain a minimum of eighteen (18) semester hours of dissertation research credit.
4. Successfully present and defend a dissertation research project proposal.
5. Advancement to candidacy will require passing both a comprehensive written and an oral qualifying examination (one each) no later than the end of the fourth semester. If a student fails one or both exams, the exam may be repeated pending approval of the graduate committee. The written examination will consist of a general topic examination and an area-of-specialization examination; the oral examination is restricted to questions that pertain to the fundamentals of the student's proposed research. The examinations are administered during the last five weeks of the Fall and Spring Semesters; to be eligible, the student must notify the graduate committee of his/her intent within the first month of the intended semester.
6. Present annual research project progress reports before the graduate committee.

7. Participate in an internship with an affiliated University Research Center, industrial collaborator or partnering national laboratory. The internship is at the discretion of the student's major professor(s) and with approval of the graduate committee.
8. Successfully submit and defend a dissertation that presents the results of original scientific research before the graduate committee.

Ph.D. candidates are also required to make seminar presentations related to their dissertation research. These can be done either on-site or by distance mode.

Program Admission:

To enter the Ph.D. program, the student must have completed an undergraduate program equivalent to that required to obtain a B.S. degree in MatSci, MS&E, or a related science or engineering field. The student's academic record must provide evidence of an adequate background in the fundamentals of science and/or engineering principles. A student that has such a background, but has not passed the prerequisite undergraduate courses that are specified for their graduate courses, must remove the course deficiencies at the onset of the student's program of study. For example, prior to enrolling for graduate credit in EGEN 585 – Advanced Mechanics of Materials, a student that has a Bachelor of Science degree in Chemistry or Physics would first need to pass the prerequisite undergraduate course (EGEN 335). Similarly, a student with a Bachelor of Science degree in Mechanical Engineering must complete the designated prerequisite courses (CHMY 401) before enrolling for graduate credit in Inorganic Chemistry and Current Literature (CHMY 553). Courses at the senior (> 400) and graduate (> 500) level that are already available are listed in Appendix III along with their course descriptions.

Internships:

As discussed above, the participation of the Ph.D. students in industrial internships with collaborating State Centers of Excellence and/or companies may form a significant part of their research experience (see Appendix I). Although it is not unreasonable for students at UM to do an internship at a company in the Butte area or for an MTech student to do an internship in Bozeman, it would be much more efficacious to have them participate in projects near their home campus. State Centers of Excellence include Center for Advanced Mineral and Metallurgical Processing (CAMP) at MTech, Center for Advanced Supramolecular and Nano Systems (CASANS) at UM and MTech, and Optical Technology Center (OPTEC), Spectrum Labs, Center for Bio-Inspired Nanomaterials (CBIN), Center for Biofilm Engineering, Center for Computational Biology, Energy Research Institute, and Western Transportation Institute, all at MSU. We have also identified materials-based companies that have expressed a willingness to have student interns near each campus. In Missoula, these companies are Purity Systems Inc., Rivertop Renewables, MicroPowder Solutions, and GT Solar. All four of these companies are involved in materials fabrications and their applications. In Butte, the most suitable companies would be AFFCO, REC Silicon, MSE-TA, Resodyn, Butte Aerotec, Polymeric Interconnect, and SeaCast. In Bozeman, the companies include Scientific Materials, Lattice Materials and Federal Technology Group. Companies in other parts of the State include Advanced Materials and Zinc Air in Kalispell and Summit Aeronautics and American ChemMet in Helena. In addition, there are several companies that are out-of-state (see Appendix II). The internship could be the main project of the student's dissertation or a separate project to be included as a chapter in the dissertation. The internships will be collaboratively supervised by a company representative and by the student's co-chairs.

B. Describe the planned implementation of the proposed program, including estimates of numbers of students at each stage.

The three institutions are prepared to initiate the Ph.D. program immediately following BOR approval. Three stages of program evolution are envisioned: Stage I – Inception and Early Program Development, Stage II – Sustained Growth, and Stage III – Program Maturity. Other than the start-up period (Stage I), the proposed program is designed to be self-sustaining throughout the later stages of development. Rather than being constrained by an unnecessarily specific time-line for moving from one stage to the next, the program's evolution will be driven by the ability of its faculty participants to secure research grants and attract, educate, and graduate increasing numbers of graduate students. In other words, the growth rate will be governed by the success of the program in obtaining and executing externally funded research programs, which in turn will provide the financial resources necessary to augment the faculty and equipment resources.

Initial projections are that as many as 15 students would enter the program during its first years of existence if sufficient funding were available. As already discussed, some of these students have already obtained or are in the process of obtaining M.S. degrees. Based upon the benchmarking study (Appendix IV), a minimum of 15 doctoral students at Stage II is a conservative estimate.

6. Resources

A. Will additional faculty resources be required to implement this program? If yes, please describe the need and indicate the plan for meeting this need.

No additional faculty resources are considered necessary to initiate the proposed program. The current faculty, laboratory space, and equipment resources are adequate to implement the program (see Appendix I) and indefinitely sustain it at the Stage I level; this fact has been proven through the current IIP program where students are following a track similar to what is proposed here. It is recognized that start-up expenses will certainly be incurred until the new participating faculty have established a threshold level of research funding. All three campuses intend to help defray these costs by strategic reinvestment of grant generated indirect costs (IDCs) and use of grant funded "buy-outs" to provide participating faculty with time necessary to write proposals and conduct seminal research necessary to develop their Ph.D. research programs during Stage I.

Additional faculty resources will be needed to elevate the program to Stage II and eventually Stage III with funding coming from grants as well as institutional support as available. To foster growth under Stages II and III, each campus envisions the need for two or more additional faculty members. The additional faculty lines would be requested based upon current program performance, future growth, and new grants and contracts.

B. Are other, additional resources required to ensure the success of the proposed program? If yes, please describe the need and indicate the plan for meeting this need.

Administration of the program includes a Program Coordinator (PC) and Advisory Boards (see Appendix V). The Program Coordinator is a participating faculty member with some AY release (e.g., one day per week). The PC is the point of contact for the program and handles the day-to-day business. The PC responsibilities include: tri-campus coordination, credit transfer issues, advertising/recruiting,

assessment, and reporting. Some administrative support will be needed as well, for advertising and recruiting, website maintenance, and communications.

Program revenue includes tuition revenue and indirect cost (IDC/F&A) generation. Besides the PC and associated administrative support, program expenses include student support via GTA's and tuition waivers, and program activities, such as an annual colloquium (over several days where the entire program faculty and students exchange technical information), teleconferences for seminars and dissertation defenses, and periodic faculty exchanges.

At Stages II and III, as the research program expands, additional administrative and technician resources will be needed in support of, and be provided by, increases in external funding. For example, the Metallurgical & Materials Engineering Department at MTech will add a half-time administrative assistant and that laboratory technicians will be added at both campuses to manage the research laboratories. Also, at some point it may be necessary to add a part-time technical writer to assist with proposal and other development.

Aside from the Stage II and III personnel needs noted above, addition of institutionally supported GTA's and tuition waivers in Stage I and II will be needed to attract the best and brightest applicants and to secure their matriculation within the program. To launch the program, two tuition waivers at each campus are requested beginning in FY 2012. When Stage II is reached, it is likely that additional institutional support will be requested including but not limited to GTA's and tuition waivers. Also in Stage II, a need for laboratory renovations on each campus is anticipated. Financing some of these renovations likely will be borne by research grants, but there is the likelihood that some institutional matching support will be required.

7. Assessment

How will the success of the program be measured?

The success of the program will be measured according to the following metrics:

- number of students that enroll in and complete the program;
- amount of funding secured;
- number of projects completed;
- number of successfully completed dissertations;
- number of publications authored by participating faculty and/or Ph.D. candidates based on original research conducted within the program;
- amount of support and feedback from our Montana industrial partners; and
- employment and career status gained by program graduates.

These statistics will be annually reviewed to ensure that the program experiences a positive and sustainable growth pattern and that it is producing high quality graduates that enhance the cultural and economic development of Montana.

8. Process Leading to Submission

Describe the process of developing and approving the proposed program. Indicate, where appropriate, involvement by faculty, students, community members, potential employers, accrediting agencies, etc.

This proposal was initially developed by a team of faculty members from MTech and UM through meetings, e-mail discussions, and several drafts of the proposal. It was reviewed on each campus by the participating

Montana Board of Regents
CURRICULUM PROPOSALS

departments, library staff, administrators of the colleges and campuses, the graduate schools, and academic affairs offices. The proposal was also submitted through the curricular governing processes and bodies of the two campuses. As the letters attached to the proposal attest (see Appendix II), several potential industrial partners had an opportunity to comment on the proposal and to identify the need for such a program in Montana. Following approval on the two campuses, MSU was notified. Subsequent meetings and e-mail discussions led to proposal expansion across the three campuses, thus proposing one degree offered by UM, MTech, and MSU using the faculty and facilities at UM, MTech, and MSU.

This proposal was reviewed and approved by the following departments/programs at The University of Montana:

Department Name: **Dept of Physics & Astronomy** Date: 9/15/2010

Department Name: **Dept of Chemistry & Biochemistry** Date: 9/15/2010

This proposal was also reviewed and approved by the following College Deans and Faculty Governance:

Dean of: **College of Arts and Sciences** Date: 9/20/2010

Dean of: **Libraries** Date: 9/15/2010

The proposal was reviewed and approved by the **Graduate Council** at The University of Montana Date: 12/2010

The proposal was reviewed and approved by the **Faculty Senate** at The University of Montana Date: 12-9-2010

[No outside consultants were employed for the development of this proposal.]

APPENDIX I – Facilities and Equipment

MTECH

MTech facilities and equipment are located in various departments across the campus. However, this description is only about the Metallurgical & Materials Engineering Department which is one of the primary departments at MTech that will participate in this Ph.D. program. It is located in the Engineering Laboratory and Classroom (ELC) Building, a three-story building constructed in 1986. The Department occupies the west wing of the first and second floors, with laboratory space on both floors and office space on the second floor. The Department is housed in approximately 20,000 square feet of space, including approximately 20 labs of various size, nine offices and one conference room. The ELC Building also houses the Center for Advanced Mineral & Metallurgical Processing (CAMP) and Center for Advanced Supramolecular and Nano Systems (CASANS).

The first floor of the ELC building is primarily lab space. On the west end of the building is a loading dock and High-Bay area, used for shipping and receiving of ores and equipment as well as short-term storage. Within the High Bay is ELC 110A (Thermal Processing Area) now housing a pilot plant roaster donated by Newmont Mining Company and ELC 111A (Roasting/Calcining Lab) housing induction, box, and kiln furnaces as well as investment and traditional casters. These units are used for both education and research.

ELC 101 (Materials Manufacturing Lab) houses a freeform fabricator, two types of porosimeters and an autoclave as well as sample preparation and wet chemistry equipment. ELC 102 houses an inductive coupled plasma (ICP) spectrometer, an ion chromatograph and a gas chromatograph. A 12-station Computer Lab and student cubicles are located in ELC 108B. ELC 109 (Separations/Recycling Lab) is used for particulate processing and includes various chemical, density, electrostatic, hydrophobic, magnetic, and particle size separators. ELC 110 (Comminution Lab) houses a variety of equipment including crushers, grinding mills, pulverizers, splitters and sieves. ELC 117 (Physical Metallurgy Lab) houses a cold pressure roll and vacuum furnace. These units are used for both education and research.

ELC 120 (Metallographic Lab 1) houses samples, microscopes and sample preparation equipment as well as a macro-hardness tester. ELC 121 (Metallographic Lab 2) houses manual polishing wheels, a submerged cut-off and diamond-blade saws. ELC 122 (Metallographic Lab 3) houses automatic polishing equipment as well as sample preparation benches. ELC 123 (Microhardness Lab) houses three microhardness testers and a Neophot. ELC 125 (Darkroom 1) houses film development equipment. ELC 126 (Imaging Lab) houses a computer aided optical microscope and a table-top imaging SEM. ELC 128 (X-Ray lab) houses X-ray Diffraction (XRD) and X-ray Fluorescent (XRF) spectrophotometers. ELC 127 (SEM Lab) houses 2 scanning electron microscopes (SEM) with one having two Energy Dispersive X-Ray analyzers attached for use as Mineral Liberation Analyzers (MLA). These units are also used for both education and research.

On the second floor of the ELC building, the department has three labs. ELC 207 (Materials Thermochemistry Lab) contains a Carbon/Sulfur analyzer, a ThermoGravimetric Analyzer (TGA), dilatometer, dynamic mechanical analyzer, scanning calorimeter and several furnaces, all for characterizing various materials but particularly polymers, ceramics, slags, composites, sulfide minerals and coals. ELC 206 (Environmental Hydrometallurgy Lab) is primarily a wet chemistry lab but also includes water purification systems, drying ovens, weighing scales and specialized equipment used for current masters projects. ELC 205A (Corrosion and Special Projects Lab) houses potentiostats, galvanostats, plating equipment, and electrochemical cells and serves as a temporary home to short-duration projects. These units are also used for both education and research.

Tables 1 and 2 list the equipment that is available. In this case, minor equipment is defined as those with purchase prices greater than $1,000 and major equipment as those greater than $15,000. It is noted that items are listed with their purchase prices and, if purchased within the last 5 years, their net book value. Those listed without net book values are older but are well maintained. Very few items are older than 25 years. Even then, only a few more items are older than 10 years.

Clearly, the facilities and equipment are adequate to support current needs of the department and the proposed Ph.D. program, at least in the near term, without sacrificing the B.S. and M.S. programs.

Table 1. Minor Equipment in Metallurgical & Materials Engineering at MTech

Item Description	Make	Purchase Price	Net Book Value
Dyna-Ble nder		$ 6,395.00	$ -
Swaging Machine 1297		$ 8,000.00	$ -
Instron-Tensometer Met 1325		$ 9,780.00	$ -
Mht.Om Ms4 Cctvk		$ 9,320.00	$ -
Jackson-Sepor Rotary Vacuum Fi		$ 8,800.00	$ -
2 Drw File Cabinet Agg42		$ 6,426.00	$ -
Wemco Cone Separator		$ 6,000.00	$ -
Auto Titrator System		$ 7,520.00	$ -
Microfocus Generator 1284		$ 13,000.00	$ -
Electromicroscope Met 1321		$ 12,914.00	$ -
1403 Moda LN2 Generator		$ 13,500.00	$ -
Graduate Panel Stations Agg 12		$ 11,518.00	$ -
Ap600 Auto Pol Sy230		$ 14,904.00	$ -
Eriez Wet High Intensity Separator	Electromagnetic	$ 13,296.98	$ 13,296.98
Digital Imaging System & Work Station		$ 9,087.00	$ 757.61
Rotating Ring Disk Electrode		$ 9,596.52	$ 3,438.82
Camera	UP 2000CL	$ 5,000.00	$ 3,874.91
Bico Ring and Puck		$ 6,715.80	$ 6,715.80
Rocklabs Ring and Puck		$ 10,930.00	$ 10,930.00
Downer EDI Spiral Separator	Walkabout	$ 3,200.00	$ 3,200.00
Microne Micronising Mill		$ 5,000.00	$ 5,000.00
Allied Abrasive Cut-Off Saw	Powercut 10	$ 5,000.00	$ 5,000.00
Eriez Dry Roll Separator	Permanent Mag	$ 9,613.76	$ 9,613.76

Table 2. Major Equipment in Metallurgical & Materials Engineering at MTech

Item Description	Make	Purchase Price	Net Book Value
High Resolution Image Collector		$ 56,604.00	$ -
Neophot21		$ 17,733.00	$ -
X-Ray Diffraction Instrument		$ 86,725.00	$ -
Kewaunee Tables 999136		$ 59,931.00	$ -
Lyon Shelving Bookcases		$ 48,999.00	$ -
Imix Update		$ 62,200.00	$ -
Induction Furnace		$ 26,455.00	$ -
Pressure Reaction Apparatus		$ 15,959.00	$ -
Sulfur/Carbon Determinator		$ 35,081.31	$ 17,248.57
Scanning Electron Microscope SEM/EDX	1430VP	$271,995.00	$133,730.57
ZEN3600 Zetasizer Nano ZS	3600	$ 31,799.30	$ 30,098.14
Prometal Powder Prototyping	R2R	$177,500.00	$133,124.90
Leo Scanning Electron Microscope	1430 Upgrade	$119,350.00	$ 94,485.50
Beckman Coulter Multisizer		$ 35,484.45	$ 35,188.75
Detector Unit, Apollo 40/Zeiss 1450VP	EDAX	$ 77,000.00	$ 76,358.33
EBSciences Turbo Carbon Evaporator	K950X	$ 21,655.93	$ 20,934.06
Phoenix S Series Fusion Machine	1000 S-VFD	$ 17,855.83	$ 17,409.43
Centorr Vacuum Sintering Furnace	Model 22-2000	$ 65,800.00	$ 65,800.00
X-Ray Fluorescence Spectrometer	Bruker A20A4	$ 73,730.00	$ 72,501.17
Eriez Carousel Magnetic Separator	Wet Electro	$ 18,559.32	$ 18,559.32
Eriez Triple Drum Magnetic Separator	Rare Earth Salient	$ 68,960.67	$ 68,386.00
Knelson Concentrator		$ 17,500	$ 17,500
Deltech High Temp Vertical Furnace	DT-31	$ donated	$ NA
Apllied Test Systems Vertical Furnace	3310	$ 31,275	$ 31,275
Apllied Test Systems Horiz Furnace	3210	$ 29,675	$ 29,675
Micromeritics Mercury Porosimeter	Autopore	$ 30,355	$ 30,355
Thermo Fisher ICP Spectrometer	ICAP 6000	$ 100,435	$ 100,435
Agilent Micro Gas Chromatograph	300A	$ 21,167	$ 21,167
FEI Desktop Imaging	Phenom	$ 60,000	$ 60,000
Hirox 3D Digital Microscope	KH-7700	$ 133,075	$ 133,075
Netsch Dilatometer	DIL 402 C	$ 151,510	$ 151,510
Arbin Instrumens PEM Fuel Cell	Educational System	$ 55, 370.00	$ 55, 370.00
TA Instruments TGA	Q5000	$ 46,702	$ 46,702
TA Instruments DMA	Q800	$ 98,939	$ 98,939
TA Instruments STA		$ 49,250	$ 49,250
Netsch STA	449 F3	$ 49,250	$ 49,250

UM

Laboratory

The participating faculty members have approximately 1000 ft^2 of laboratory space fully equipped for the synthetic and analytical work proposed. In addition to standard laboratory equipment the laboratory has a new Vacuum Atmospheres glove box, high vacuum lines and a computer controlled electrochemical apparatus. Through the Departments of Chemistry and Geology the PI has access to AA, ICP and ICP-MS analytical instrumentation.

Computers

There are four desktop computers in the laboratory for group use and three laptop computers for personal use. The Core Computational Facility located next door to the chemistry building has a 2 octane 3000 computers for the molecular modeling studies with the associated software SYBYL 7.0 (Tripos, St Louis, MO), and AMBER 8.0 (Peter Kollman, UCSF) and Materials Studio, (Accelrys, San Diego, CA).

Major Instrumentation

The Department of Chemistry has two Varian NMR spectrometers operating at 500 and 600 MHz. The 500 MHz instrument is used for solution multinuclear experiments and is equipped with solid state CPMAS components and a triple resonance probe with field gradients and the 600 MHz instrument is equipped with a cold probe and with enhanced ^{13}C sensitivity and special sample equipment for high salt protein solutions. SEM/EDX and TEM is available at the electron microscopy lab in the Biology Department on a Hitachi S–4700 Type II . The Department also has a Thermo Nicolet 633 FT IR equipped with ATR and diffuse reflectance accessories. X-ray powder diffraction equipment is available through the Geology department on a Panalytical X'-Pert Pro.

Two 6890/5973 Agilent GC/MS
5890 HP GC
Thermo S-series atomic absorption spectrophotometer (AA).
1090 Agilent HPLC
Shimadzu GC-17A
Nicolet Nexus 670 FT-IR
Shimadzu RF-1501 spectrofluorophotometer
Three Agilent 3D capillary electrophoresis instruments
Three Molecular Devices 96 well plate UV-Vis/Fluorescence spectrophotometers

The University of Montana Spectroscopy Core Laboratory

Wet Laboratory for Core (840 square feet):
- pH meter, balance and microbalance
- -20 freezer, -80C freezer, refrigerator, fume hood, refrigerated chromatography cabinet
- chromatography and gel electrophoresis equipment, FPLC
- temperature-controlled shaker for protein expression, sonicator table-top centrifuge

Additional Departmental/Institutional Resources for Sample Preparation:
- cold rooms, refrigerated preparative and ultra centrifuges, lyophilizers, microscopes
- HPLCs, specialized electrophoresis systems, crushed and dry ice

Spectroscopy Laboratory Computers

- Server (365 GB) housed in Molecular Computational Core Facility (J. Gerdes, Director)
- 6 PC workstations (2-GHz); server and PCs connected by LAN

Spectroscopy Laboratory Steady-State Major Instrumentation

- dual-beam UV/VIS absorption spectrophotometer
- SPEX-based steady-state fluorometer:
  1. single-photon counting electronics constructed in-house
  2. equipped with Glan-Thompson polarizers for steady-state anisotropy measurements
  3. thermostated high-pressure cell for studying high-affinity systems (1 - 2,500 bar)
  4. thermostated cuvette holders: Quantum Northwest TLC50

Spectroscopy Laboratory Ultra-fast Laser Facility[1] (450 square feet):

- Coherent ps laser system: 10 W diode laser (Verde) pumping a Ti:Sapphire laser (Mira)
  1. IR light pulses tunable between ~680 and ~1050 nm
  2. second and third harmonic generation: UV-visible light tunable from ~260 to ~520 nm
  3. frequency doubled optical parametric oscillator (OPO) generates ~520 to ~650 nm light
- Coherent fs IR laser (Chameleon) dedicated for two- and three-photon microscopy
- PicoQuant ps 470-nm Laser Diode
- Time-correlated, single-photon counting (TCSPC) time-resolved anisotropy spectrometer designed and constructed in collaboration with Quantum Northwest, Inc. (Spokane, WA)
  1. modified format for *simultaneous* collection of three decay curves: V, H, magic angle
  2. each emission train can use monochromators or filter
  3. each emission train has dedicated PMT and TCSPC processing electronics
  4. sample chamber can accommodate different sample holders, including the high-pressure cell (up to 3 kbar), a goniometer, or a 5-position automated thermostatted cuvette holder
- Nikon TE2000-U inverted fluorescence microscope
  1. time-resolved fluorescence anisotropy and emission spectroscopy
  2. direct laser excitation and total internal reflectance fluorescence (TIRF) excitation
- Olympus IX71 inverted microscope with FluoView 300 confocal scan-head
  1. multi-and single-photon imaging
  2. fluorescence lifetime imaging(FLIM), FRET and FCS
- two-channel correlator (TimeHarp 200, Picoquant, Inc.) that generates time-tagged time-resolved (TTTR) data for TCSPC, FCS, FLIM or FRET

Machine Shop (housed in Chemistry Department)

- band saw, drill press, lathe, mill, and tools to machine light metals, plastics, wood

Electronics Shop (housed in Physics Department)

- Available as needed – Core has minor electronics (i.e., oscilloscope, signal generator)

[1] The ultra-fast laser facility is equipped with electrical protection. Constant temperature and clean air protect the optics and electronics, assuring stable operation.

MSU

Montana State University's facilities and equipment that support materials science and engineering research are distributed through the College of Engineering and the College of Letters and Science. MSU researchers have access to several user facilities http://www.montana.edu/wwwvr/userfacilities.html across campus to utilize Materials Science and Engineering related tools such as those included in the

- Center for Biofilm Engineering Microscopy Facility,
- Chemistry and Proteomics & Mass Spectrometry Facility,
- Image and Chemical Analysis Laboratory (ICAL),
- Ion Beam Group,
- Montana Microfabrication Facility (MMF), and
- Nuclear Magnetic Resonance Laboratory.

Furthermore, the multi-disciplinary materials research at MSU through programs such as the

- Energy Research Institute (ERI),
- Center for Bio-Inspired Materials (CBIN), and
- Center for Bio-film Engineering

provide access to individual researchers laboratories for which many additional and unique tools are available. These core user facilities combined with individual laboratory contributions place MSU materials science and engineering research capabilities at levels that meet or exceed Universities that currently offer Ph.D. programs in materials.

Key materials science and engineering related equipment available at MSU is categorized below:

Processing (Bulk/Thin Film): Multiple high temperature box and tube furnaces with full atmosphere control up to 2200C, mixing/homogenizing systems (ball mills, planetary mills, ultrasonic), tape casting, screen printing, spin coating, dip coating, electro/chemical plating, particle size analysis (nano to micro scale), rheological (viscosity) measurement systems, Pulsed Laser Deposition (PLD), Electron Beam Evaporation, DC/RF Sputtering, and Metal-Organic Chemical Vapor Deposition (MO-CVD).

Thermal Analysis: High temperature, up to 1600C, atmosphere controlled dilatometer and DTA/TGA with evolved gas analysis (mass spec).

Image/Chemical/Structure/Performance Characterization: Atomic Force Microscopy (AFM), Scanning Electron Microscopy (FE-SEM) with energy dispersive spectroscopy (EDS), X-ray Diffrication (XRD), Transmission Electron Microscopy (TEM), Raman Spectroscopy (UV & optical), X-ray Photoelectron Spectroscopy (XPS), X-ray Absorption Spectroscopy (XAS), X-ray Crystallography, Rutherford Backscattering (RBS), Time-of-Flight Secondary Ion Mass Spectrometry(ToF-SIMS), Scanning Auger Electron Microprobe (AUGER), Nuclear Reaction Analysis (NRA), Confocal Scanning Laser Microscopy (CSLM), Magnetic Resonance Microscopy (MRM), Nuclear Magnetic Resonance (NMR), Laser Doppler Vibrometer, High Resolution Digital Image Correlation System, Magnetic Properties Measurement System (MPMS), Induction Coupled Plasma (ICP), a variety of Mass Spectroscopy systems, multiple electrochemical testing systems.

Microfabrication: Deposition, Etching, Lithography, Metrology, and Packaging capabilities within Class 1000 and Class 10,000 cleanrooms.

APPENDIX II – List of Participating Institutions and Example Letters of Support

In-State Industry

- John Krstulich, GT Solar, Missoula
- Yuval Avniel, MicroPowder Solutions LLC, Missoula
- Larry Twidwell, Montana Enviromet, Butte
- Jeff Ruffner, MSE-TA, Butte
- Hugh Craig, Polymeric Interconnect, Butte
- Tom McIntyre, REC Silicon, Butte
- Lawrence Farrar, Resodyn Corporation, Butte
- Craig Wilkins, Zinc Air, Inc., Kalispell
- Dan Brimhall, American ChemMet, Helena
- David Briggs, Purity Systems, Inc., Missoula
- Todd Johnson, Federal Technology Group, Bozeman
- Don Kiely, Rivertop Renewables, Missoula
- Hank Rawlins, Montana Process Engineering, Butte
- Jim Liebetrau, AFFCO, Anaconda
- Bert Robins, SeaCast, Butte
- Arif Karabeyoglu, AeroTec, Butte
- Dave Micheletti, Universal Technical Resource Services (UTRS), Butte
- Don Profota, Lattice Materials, Bozeman
- Randy Equall, Scientific Materials Corporation, Bozeman
- Howard Bateman, Advanced Materials (Semi-Tool), Kalispell
- Tom Hoffman, Summit Aeronatics Group (Boeing Fabrication), Helena

Out-of-State Industry

- Tim Hildebrand, Exotic Metals Forming, Kent, WA
- Gary Tuss, Boeing Materials, Seattle, WA
- Brian Sullivan, REC Silicon, Moses Lake, WA
- Jeff Immelt, General Electric, Fairfield, CT
- George Nguyen, Bloom Energy, Sunnyvale, CA
- Marc LeVier, Newmont Mining Corporation, Denver, CO
- John Quinn, Freeport McMoRan, El Paso, TX
- Larry Watters, Taggart Global, Pittsburgh, PA
- Mike Garska, Imerys, Sandersville, GA
- Hugh Craig (contact), DuPont, Willmington, DE

State Centers of Excellence

<u>MTECH</u>

- Center for Advanced Mineral and Metallurgical Processing (CAMP)

<u>UM</u>

- Center for Advanced Supramolecular and Nano Systems (CASANS)

MSU

- Optical Technology Center (OPTEC)
- Spectrum Labs
- Center for Bio-Inspired Nanomaterials (CBIN)
- Center for Bio-Film Engineering
- Center for Computational Biology
- Energy Research Institute
- Western Transportation Institute

Federal Departments, Agencies and Laboratories

- Department of Defense (DoD)
- Department of Energy (DoE)
- National Aeronautics and Space Administration (NASA)
- National Science Foundation (NSF)
- National Institutes of Health (NIH)
- Idaho National Laboratory (INL)
- Pacific Northwest National Laboratory (PNNL)

Many of these participating institutions wrote letters of support, attached at the end. In addition, many of these participating institutions helped fund past and/or are funding past and current research activities.

APPENDIX III – Courses at UM, MTech and MSU

MTECH COURSES (Lecture):

CHMY 5506 POLYMER CHEMISTRY (3 cr). Covers the structure, synthesis, kinetics, distribution, conformations, and morphology of polymers. Prerequisites: CHMY 210 or 323 and 373. (2nd, Alt)

EGEN 476 NONDESTRUCTIVE EXAMINATION 3 Cr. (Hrs: 2 Lec, 1 Lab). Introduction to Nondestructive Evaluations techniques including theory and application of visual, dye-penetrant, magnetic particle, eddy current, ultrasonic and x-ray techniques. Prerequisites: PHSX 237 (2nd)

EGEN 535 EXPERIMENTAL STRESS ANALYSIS (3 cr). Experimental stress analysis emphasizes the determination of strains, stresses and the directions of maximum stresses by experimental methods. Electronic strain gage application is studied in depth, and other topics include strain measurement by mechanical methods, photoelasticity, brittle coatings and structural models.

EGEN 584 REINFORCED CONCRETE DESIGN (3 cr). An introduction to the design of reinforced concrete beams, columns and footing will be made. Single reinforced, double reinforced and T-beams will be designed for both bending and shear. Column design will include both tied and spiral re¬inforced columns. The class will include the analysis and design of a three-story reinforced concrete building frame with beam, column and footing designs.

EGEN 585 ADVANCED MECHANICS OF MATERIALS (3 cr). Considers advanced strength topics and reviews elementary strength of materials. Topics considered are beam deflections, statically indeterminate beams, fatigue, two and three dimensional Mohr's circle stress problems, advanced beam topics (shear center, unsymmetrical bending, curved flexural members, beams on elastic foundations, nonlinear stress-strain diagrams), advanced torsion problems, thick-walled pressure vessels, rotating disks, contact stresses and stress concentrations, elastic and geometric stability.

EMET 401 PROCESSING OF AQUEOUS SYSTEMS 3 Cr. (Hrs.:.:3 Lec.) Chemistry and operating principles related to hydrometallurgical and electrometallurgical unit operations are illustrated and discussed for industrial processes. Acid rock drainage formation and treatment methods are examined. Physical and chemical principles as well as design criteria are discussed and examined from an operational approach throughout. Hydrometallurgical processes commonly used for concentrating include traditional leaching (dump, heap, vat and agitation), bacterial leaching, solvent extraction, ion exchange, and reduction (cementation, electrowinning and gaseous reduction). Electrometallurgical processes commonly used for purifying include electrothermic, electrolytic, electrowinning and electrorefining methods. Prerequisites: M&ME 3220 or Consent. (1st)

EMAT 402 PROCESSING OF ELEVATED TEMPERATURE SYSTEMS 3 Cr. (Hrs: 3 Lec.) Basic engineering principles are used to explain the production of metals from ores by high temperature processes. Topics include drying, calcining, roasting, sintering, agglomeration, smelting, converting and refining. Applications to lime and cement manufacturing are covered in detail and include heat balances and field trips. Waste production, waste treatment and environmental controls are illustrated and discussed. Prerequisite: M&ME 3220 or Consent of Instructor. (1st)

EMAT 462 CERAMIC MATERIALS 2 Cr. (Hrs: 2 Lec.) Deals with processing and properties of ceramic solids pertinent to there use as engineering materials, thermal, mechanical, and electrical properties and there

relationships to microstructure, crystal structure and phase equilibria. Prerequisite: M&ME 3510 or Consent of Instructor. (2nd)

EMAT 471 MATERIALS CHARACTERIZATION & ANALYSIS 3 Cr.. (Hrs: 2 Lec., 3 Lab) This course provides an introduction to the theory of X-ray Diffraction (XRD), Inductively Coupled Plasma (ICP) Spectrometry, and Scanning Electron Microscopy/Energy Dispersive X-ray (SEM/EDX) Microanalysis and includes a laboratory component where the techniques for data collection and data interpretation are demonstrated and discussed. Students must register for METE 4710 Lab. Prerequisite: Senior standing or Consent of Instructor. (2nd)

EMAT 475 ENVIRONMENTAL DEGRADATION OF MATERIALS 3 Cr. (Hrs: 3 Lec.) An introduction to the study of the degradation of materials and how it may be retarded or prevented. Applications to metals (i.e., corrosion) as well as to plastics and coatings are detailed. The student will be required to submit a report identifying an industrial corrosion problem, the form of the degradation, collecting literature concerning recent research dealing with the particular form, formulating a recommended solution to the problem, providing an estimate of the cost of the proposed solution, and reporting the results in an acceptable final report. Prerequisites: M&ME 3320 or CHMY 371 or Consent of Instructor. (1st)

EMAT 486 POLYMERIC MATERIALS 2 Cr. (Hrs: 2 Lec.) Covers chemical structure, mechanical and other properties related to the use of polymeric materials for engineering applications. Design considerations unique to polymeric materials are presented and applied. Prerequisite: M&ME 3510 or Consent of Instructor. (1st)

EMET 501 ADVANCED EXTRACTIVE METALLURGY I 3 Cr.. (Hrs.:.:3 Lec.) A detailed study of the design, simulation and analysis for metallurgical and mineral processing unit operations and research including problems and treatment methods associated with mine waste. Prerequisite: Consent of Instructor. (2nd, even yrs)

EMET 502 ADVANCED EXTRACTIVE METALLURGY II 3 Cr.. (Hrs.:.:3 Lec.) Continuation of MetE 5010 but can be taken out of sequence. Prerequisite: Consent of Instructor. (1st, even yrs)

EMET 504 FIRE ASSAY 2 Cr. (Hrs:1.5 Lec.;1.5 Lab) This laboratory/lecture course covers the art and science of assaying for precious metals. Procedural differences are discussed for various ore types as well as the precious metal being assayed. In this regard, gold, silver, rhodium, platinum and palladium assay methods are compared. Field trips to area mines and smelters will be made. Students must register in MetE 5040 Lab. Prerequisite: Consent of Instructor. (1st, 2nd, Summer)

EMET 511 MATERIALS HANDLING DESIGN 3 Cr.. (Hrs.:.:2 Lec.;3 Lab.) A design-oriented course covering belt conveyors, feeders, storage facilities, slurry pipelines and pumps. Spreadsheet calculations are used to design belt conveyors and slurry pipelines based on laboratory data obtained from samples collected at industrial sites. Prerequisite: Consent of Instructor. (2nd, even yrs)

EMAT 523 ADVANCED THERMODYNAMICS (3 cr). Application of solution thermodynamics to metallurgical and materials systems is examined with particular emphasis on the construction, interpretation, and utilization of multiple component phase diagrams. (1st, odd numbered yrs)

EMET 525 COMPUTER APPLICATIONS FOR PROCESS ENGINEERS 3 Cr.. (Hrs.:.:2 Lec.:3 Lab) An application of computer techniques to processes engineering including optimizations, mass balances, energy balances, thermodynamics, and simulations. Prerequisites: Consent of Instructor. (1st, odd yrs)

EMET 526 THERMODYNAMIC MODELING OF AQUEOUS SYSTEMS (3 cr). An application of computer techniques to process engineering including organizations, mass balances, energy balances, thermodynamics, and simulations (1st , odd numbered yrs).

EMET 531 HAZARDOUS AND TOXIC SPECIES REMEDIATION 3 Cr.. (Hrs.:.:3 Lec.) Fundamental considerations and current industrial unit operations used in treating solutions and solids that contain toxic and hazardous constituents, e.g., arsenic, selenium, thallium, mercury, and heavy metals are reviewed. Students will be able to: describe the fundamental basis for currently used industrial treatment processes for removing toxic and hazardous constituents from solutions and/or stabilizing solids; describe the unit operations utilized in the treatment of toxic and hazardous constituents; select the best unit operations for the processing of waste solutions and solids; and describe, compare and suggest possible alternative treatment processes to presently used industrial processes. Prerequisite: Consent of Instructor. (1st, odd yrs)

EMET 534 PROCESSING OF PRIMARY AND SECONDARY RESOURCES (3 cr). This course describes the physical and chemical processes involved in separations. Flotation, the most commonly used separation technology, is discussed in detail. Gravity, magnetic and electrostatic separations are also described, Strategies involving non-mineral systems (recycling and waste minimization) are introduced and corresponding laboratory exercises are conducted. Students must register for METE 5340 Lab (1st, even yrs).

EMAT 541 FLOWSHEET DEVELOPMENT & Design 3 Cr.. (Hrs.:.:2 Lec, 3 Lab) The course presents the fundamentals of process development from the perspective of balancing the technical and economic viability with sustainable materials and natural resource management. Emphasis is placed on process design techniques that achieve efficient and economic utilization of raw materials, water, and energy and thereby conserve natural resources and minimize waste production. Each student selects a specific process and develops an interactive spreadsheet model that incorporates the flow sheet, mass and energy balances, equipment sizes, and first order capital and operating cost estimates. Students are welcome to choose from chemical (organic or petroleum, in particular), environmental (pollution control and/or waste treatment), manufacturing, materials, mineral processing, metallurgical, recycling, and other commercially relevant processes. Prerequisite: Consent of Instructor. (2nd, odd yrs)

EMET 544 CASTING AND SOLIDIFICATION (3 cr). Theory of solidification is reviewed including heat flow, nucleation and growth kinetics, solute distribution, constitutional undercooling, and grain and sub-grain structure. Both micro and macro forms of segregation are examined. Different casting methods and molding materials are characterized and compared. Casting concerns and special handling techniques for particular alloy systems are discussed. Methodologies for mold design are covered. Feeding, gating, and risering systems are studied with the aid of fluid dynamics. Models regarding the formation of casting defects, porosity, and hot-tearing are outlined. Students must prepare an extensive literature review on a select topic. (Odd numbered yrs)

EMET 555 ADVANCED FLOTATION (3 cr). Deals with the development of the theoretical basis of the flotation process. The surface chemistry of collector and frother action under modification is quantitatively presented. Modern theories of absorption are critically examined. (On demand)

EMAT 569 FAILURE ANALYSIS & DESIGN LIFE (3 cr). Application of the principles of physical and mechanical metallurgy to failure analysis. Methodologies are developed to solve failures including an analysis of stress state and loading. Fractography is characterized for different types of failure. Models for crack initiation and crack propagation are presented. The role of corrosion on design life is considered. Principles of

nondestructive evaluation are introduced. Case histories of past failures are reviewed and analyzed. Students must prepare a comprehensive literature review on a selected topic. (1st, even yrs)

EMAT 570 MECHANICAL BEHAVIOR OF MATERIALS (3 cr). Treats mechanical properties and behavior of materials with regard to stress and strain. Plastic deformation of crystalline materials is considered. Relationships between microstructure and mechanical strength are developed. Mechanisms for fracture, creep, and fatigue are examined. (1st, odd yrs)

EMAT 571 SEM/EDX (2 cr; lecture + lab). Continuation of METE 4710 with a complete focus on materials characterization and analysis by Scanning Electron Microscopy and Energy Dispersive X-Ray (SEM/EDX). Theory, principles, and techniques are presented in detail. Enrollment will be limited. (1st, even yrs)

EMAT 580 NANOSCALE MATERIALS & TECHNOLOGY (3 cr; lecture + lab). Examines the technology and creation of functional materials, devices, and systems through the control of matter o the nanometer scale (1-100 nm) from the top down as well as the bottom up including exploitation of novel phenomena and properties (physical, chemical, biological, mechanical, and electrical). (2nd, odd yrs)

EMET 582 PROCESSING OF ENERGY RESOURCES (3 cr; lecture + lab). Focuses on coal and uranium processing including discussions on environmental issues. Coal topics include genesis, macerals, properties, washability analysis, beneficiation principles, levels of preparation, beneficiation equipment, preparation economics, power plant operations, blending and fractionation. Spreadsheet calculations involving comminution modeling and coal drying are developed. Labs on maceral identification, hardness, washability, carbon/sulfur analysis, and BTU measurements are conducted. Uranium topics include mineralogy, leaching practices, solution concentration and purification. Nuclear power plant operations are touched upon. Students will conduct library searches and write reports on other energy resources excluding oil. (2nd, odd yrs)

EMET 583 PROCESSING OF PRECIOUS METAL RESOURCES 3 Cr.. (Hrs.:.:2.5 Lec.;1.5 Lab) An introduction to the processing and hydrometallurgy of precious metal ores with a focus on gold. Lectures cover crushing, grinding, autoclaving, agglomeration, roasting, concentration, leaching, solution purification, recovery, cementation, electrowinning and recycling. Environmental concerns and industrial solutions are emphasized. The laboratory experience consists of visiting gold processing facilities, collecting processing data from each plant, and writing summary trip reports. Prerequisite: Consent of Instructor. (1st, odd yrs)

EMAT 584 ELECTRICAL, OPTICAL, AND MAGNETIC PROPERTIES OF MATERIALS (2 cr). Concepts introduced at the undergraduate level are expanded upon relative to the electrical, magnetic, and optical properties of materials. Topics include the electron properties as a particle and as a wave, bonding, free electron theory, bond theory of solids, semiconductors, dielectric materials, magnetic materials, lasers, and superconductors (Odd numbered yrs)

EMET 595 SPECIAL TOPICS: ADVANCED PYROPROCESSING (3 cr). The course focuses on the analysis of selected pyrometallurgical and thermal processes and includes the application and integration of applicable environmental control technologies and efficient energy utilization practices. Emphasis is placed on the utilization of thermodynamic, kinetic, and engineering principles in process development, design, and operation applications.

EMAT 595 SPECIAL TOPICS: BIOMATERIALS (new Course) 3 Cr. (Hrs: 3 Lec.) Covers selected topics of specific interest in the field of metallurgical and materials engineering. The topic will be designated at the time it is offered. May meet with METE 4950. Prerequisite: Consent of Instructor. (On Dem.)

EWLD 443 PHYSICS OF WELDING 3 Cr.. (Hrs.:.:2 Lec.; 1 lab) This course covers the physical processes underlying most welding processes including primary energy sources, thermal sources, shielding requirements and the application of force or pressure. Specific topics include an atomic view of welding, the requirements for chemical bonding (coalescence), heat source/material interactions, arc physics, 2- and 3-D heat flow, mass flow, melting and solidification and the development of residual stresses. The lab portion makes use of demonstrations and engineering measurement exercises to complement the discussion of welding physics lectures. Computerized data collection equipment is used to record raw data from welding processes (primarily arc welding processes). The data is then analyzed to extract meaningful engineering information and correlated to weld properties. Lab exercises include measurements of weld heat-affected zone thermal cycles, solidification and cooling rate, heat source and melting efficiencies and weld pool geometry. Prerequisites: WLDG 362 (1st)

EWLD 488 THE METALLURGY OF FERROUS WELDS 3 Cr. (Hrs.:3 Lec.) Course is offered by M&ME and covers arc welding processes, including physics of the arc, heat flow, chemical reactions in the weld metal, weld pool mechanics, and residual stresses. Microstructures within the various zones in a weld (weld metal, partially melted zone, and heat-affected zone) are characterized for ferrous alloys (carbon, alloy, and stainless steel). Weld defects are characterized and weldability tests are examined. Prerequisite: EMAT 351 or Consent. (2nd, odd yrs)

EWLD 587 DESIGN OF WELDMENTS 3 Cr. (Hrs.: 3 Lec.) Course is offered by M&ME and covers the origin, measurement, and mitigation of weld residual stresses. Standard guidelines for weld design will be covered with regard to strength, toughness, and fatigue. Design allowables will be considered. The effect of microstructure, joint design, bead shape, distortion, and defects on the tensile strength of weldments will be characterized. Application of fracture mechanics will be discussed. Prerequisite: Senior or Graduate Standing and Consent. (2nd)

EWLD 589 METALLURGY OF NON-FERROUS WELDS 3 Cr. (Hrs.:3 Lec.) Course is offered by M&ME and covers welding processes applicable to aerospace materials such as titanium, aluminum, refectory metals, and super-alloys. Applicability of Soldering, Brazing, Electron Beam, and Laser Beam techniques to various alloy systems are discussed, with emphasis on control of thermal cycles, dilution, and weld contamination. Metallurgical fundamentals of the alloy systems are emphasized with extensive use of phase diagrams. Prerequisite: Senior or Graduate Standing and Consent. (1st)

STAT 441 EXPERIMENTAL DESIGN 3 Cr.. (Hrs.:.:3 Lec.) Studies concepts and applications of the collection of data and proper design of experiments. Aspects of design, sampling principles, exploratory data analysis, confidence intervals and hypothesis testing and basic experimental designs will be taught. The importance of randomization, replication, and methods for reducing experimental error will be emphasized. Prerequisite: STAT 131 or 216 or 332. (1st)

STAT 435 STATISTICAL COMPUTING & EXPLORATORY DATA ANALYSIS 3 Cr.. (Hrs.:.:3 Lec.) Techniques available to the statistician for efficient use of the computer to perform data management and exploratory statistical analyses. Programming statistical software for the import and export of data, variable sorting, creation of new variables, descriptive statistics and displaying data efficiently are discussed. Special modern statistical topics including bootstrapping and nonparametric modeling are discussed. Prerequisites: STAT 131, 216, 332, or a first course in statistics. (2nd)

MTECH COURSES (Self-Paced)

EMAT 520 PHYSICAL CHEMISTRY OF IRON & Steelmaking 3 Cr. (Hrs.:.:3 Lec.) Physical chemistry principles are utilized to describe iron and steel production including refining as well as slag/refractory selection and stability. Environmental issues are emphasized. Prerequisites: Consent of Instructor. (1st, 2nd, Summer)

UM COURSES (Lecture)

CHMY 445 INDUSTRIAL CHEMISTRY AND ITS IMPACT ON SOCIETY (3 cr). Offered every other autumn semester. Prereq., CHMY 143 or 123 (CHEM 162 or 152). A course based on local Montana chemical industries involving field trips to chemical plants, visits by company personnel and an overall evaluation of the company's economic and environmental impact on the community.

CHMY 542 SEPARATION SCIENCE (3 cr). Offered autumn odd-numbered years. Prereq., CHMY 421 (CHEM 342), CHMY 360 (CHEM 370) or 373 (CHEM 371). Theory, method development, and application of analytical separations; solvent extraction; solid phase extraction; various forms of chromatography; electrophoresis.

CHMY 553 INORGANIC CHEMISTRY AND CURRENT LITERATURE (4 cr). Offered spring. Prereq., CHMY 401 (CHEM 452). A survey of the elements including transition metal reaction mechanisms, redox chemistry, organomatallic chemistry, bioinorganic chemistry. Oral and written presentations on primary literature.

CHMY 403 DESCRIPTIVE INORGANIC CHEMISTRY (3 cr). Offered spring. Prereq., CHMY 221-222, 360 or 373-371, and 401 (CHEM 221-223, 370 or 371-373 and 401). A survey of the chemistry of the elements including transition metal reaction mechanisms, redox chemistry, organometallic chemistry, bioinorganic chemistry.

PHYSICS 446 THERMODYNAMICS AND STATISTICAL MECHANICS (3 cr). Offered autumn odd-numbered years. Prereq., PHYS 341; coreq., M 311. Topics in thermodynamics and statistical mechanics.

PHYSICS 463 SELECTED TOPICS IN MODERN PHYSICS (3 cr). (R-6) Offered intermittently. Prereq., PHYS 461 or consent of instr. Studies of a topic in advanced modern physics including nuclear physics, solid state physics, and quantum optics. The topic chosen will vary according to instructor.

PHYSICS 444 ADVANCED PHYSICS LABORATORY (3 cr). Offered spring. Prereq., PHYS 341 or equiv., PHYS 325 or equiv.; PHYS 321 suggested but not required. Advanced experiments in classical and modern physics, including optics, spectroscopy, laser science, atomic, nuclear, and particle physics, Data analysis techniques for experimental scientists. Recommended for students entering graduate school in any experimental science.

UM COURSES (Online):

CHMY 595B (new course) **FUNCTIONAL NANOMATERIALS** (3 cr). An interdisciplinary course taught by two instructors, one from UM and one from MTech that surveys the applications of nanoscaled materials in biology, electronics, environmental sensing and medicine. Emphasis is on the synthesis of the materials and their practical applications

PHYSICS 495b (new course) **PROPERTIES OF MATERIALS** (3cr). An interdisciplinary course that deals with the properties of specialized materials and includes microfabricated materials, organic-inorganic hybrid materials, superconducting and magnetic materials

MSU COURSES (Lecture):

CHMY 401 ADVANCED INORGANIC CHEMISTRY S 3 cr. LEC 3, COREQUISITE: CHMY 361 or CHMY 373. A systematic presentation of atomic structure and chemical bonding with emphasis on properties, structure, and the reactions of representative members of the various families of the periodic table.

CHMY 417 SYNTHETIC CHEMISTRY F alternate years, 3 cr. LEC 3, PREREQUISITE: CHMY 323. Organic and inorganic reaction chemistry for advanced students. Modern reagents and transformations are treated in detail, along with relevant theoretical and mechanistic considerations.

CHMY 421 ADVANCED INSTRUMENT ANALYSIS F, alternate years 3 cr. LEC 2 LAB 1, PREREQUISITE: CHMY 361 or CHMY 371. An advanced analytical chemistry course which covers modern instrumental methods based on spectroChemical and electrochemical principles.

CHMY 515 STRUCTURE AND BONDING IN INORGANIC CHEMISTRY F 3 cr. LEC 3, PREREQUISITE: CHMY 401. Spectroscopy, structure, and bonding of coordination and organometallic compounds.

CHMY 516 MECHANISMS AND DYNAMICS IN INORGANIC CHEMISTRY S 3 cr. LEC 3, PREREQUISITE: CHMY 401. Mechanisms and dynamics of the reactions of coordination and organometallic compounds.

CHMY 524 MASS SPECTROMETRY F alternate years, 3 cr. LEC 3, PREREQUISITE: CHMY 371 or CHMY 361. Mass spectrometric methods of analysis. Methods for ionization of samples in the gas, liquid and solid phases. Proteomics applications. Cross-listed with BCHM 524.

CHMY 527 OPTICAL SPECTROSCOPY F alternate years, 3 cr. LEC 3, PREREQUISITE: CHMY 371. Use of optical spectroscopic methods for chemical analysis.

CHMY 540 ORGANIC SYNTHESIS F 3 cr. LEC 3, PREREQUISITE: CHMY 533 and CHMY 535. A thorough study of strategies for the synthesis of complex natural products.

CHMY 554 ORGANOMETALLIC CHEMISTRY S alternate years, 3 cr. LEC 3, PREREQUISITE: CHMY 321, CHMY 323 and CHMY 553. Application of organometallic chemistry to organic transformations.

CHMY 559 KINETICS AND DYNAMICS S alternate years, 3 cr. LEC 3, PREREQUISITE: CHMY 373 or equivalent. Chemical kinetics, theories of reaction rates, molecular reaction dynamics, with applications to Chemical reactions in the gas phase, on surfaces, and in solution.

ECHM 424 TRANSPORT ANALYSIS F 3 cr. LEC 3, PREREQUISITE: ECHM 323, M 273Q, M 274. Deterministic modeling techniques are applied to processes for the transport of momentum, energy and mass. Analytical and numerical solution techniques for the differential equations commonly encountered in the transport processes.

ECHM 438 BIOPROCESS ENGINEERING S 3 cr. LEC 3, PREREQUISITE: BCHM 340 or BIOM 360 and CHBE 216. Biotechnology process engineering - microbial process fundamentals, enzyme catalysis, bioreactor design and analysis, separation of biomaterials.

ECHM 503 THERMODYNAMICS F 3 cr. LEC 3, PREREQUISITE: ECHM 307. Chemical engineering application to phase equilibria and chemical reaction equilibrium. Liquid - liquid, vapor - liquid, and multiple reaction system.

ECHM 533 TRANSPORT PHENOMENA S 3 cr. LEC 3, PREREQUISITE: ECHM 424. Comprehensive treatment of mass, momentum, and energy transport. Cross listed with ME 533.

EELE 505 MEMS SENSORS AND ACTUATORS S alternate years, 3 cr. LEC 2 LAB 1, PREREQUISITE:

EELE 409. MICRO FABRICATION OF ELECTRICAL AND MECHANICAL DEVICES. Theory of various mechanical transducers and physical sensors including optical MEMS, RF MEMS, and Bio/Chemical MEMS.

EELE 555 ALTERNATIVE ENERGY DISTRIBUTED GENERATION SYSTEMS S alternate years, 3 cr. LEC 3, PREREQUISITE: EELE 355. Exploration and analysis of alternative power generation sources and systems such as wind, solar, microturbine, and fuel cells, combined sources and their design, power electronic interfacing, and energy storage systems.

EGEN 541 THEORY OF MAGNETIC RESONANCE IMAGING I F,S 3 cr LEC 3, PREREQUISITE: Graduate standing, or consent of instructor. Advanced topics in NMR phenomena including relaxation, diffusion, chemical shift, and magnetic susceptibility, as well as experimental aspects including phase cycling, magnetic field gradients, rf coil, tuning and matching and pulse sequence development will be covered.

EMAT 452 ADVANCED ENGINEERING MATERIALS On Demand 3 cr. LEC 3, PREREQUISITE: EMEC 250 or equivalent. Advanced consideration of the structure and behavior of metals.

EMAT 460 POLYMERIC MATERIALS F 3 cr. LEC 3, PREREQUISITE: EMAT 251, ECHM 215. The nature and special characteristics of synthetic high polymers and the technology of their manufacture and processing.

EMAT 463 COMPOSITE MATERIALS F alternate years, 3 cr. LEC 3, PREREQUISITE: EMAT 251. Structure and properties of composite materials and design procedures for composite structures. Cross-listed with EMAT 463.

EMAT 511 CATALYSIS AND APPLIED SURFACE CHEMISTRY On Demand 3 cr. LEC 3, REREQUISITE: ECHM 328. The fundamental principles of catalysis, surface chemistry, and reactor design at a working research level.

EMAT 519 SURFACE ENGINEERING On Demand 3 cr. LEC 2 LAB 1, PREREQUISITE: Graduate standing. Consideration of chemistry and instrumentation needed in engineering design and research, including surface science, and materials.

EMAT 550 FAILURE OF MATERIALS Odd years, S 3 cr. LEC 3, PREREQUISITE: One of the following: EMAT 463, EGEN 415, EMAT 452.

EMAT 551 ADVANCED COMPOSITE MATERIALS S alternate years 3 cr. LEC 3 PREREQUISITE: EMAT 463. Advanced treatment of composite materials, including constituent properties, interfaces, micromechanics, microscopic behavior, modes and mechanisms of failure.

EMAT 552 ADVANCED CERAMICS F, alternate years, 3 cr. LEC 3, PREREQUISITE: EMAT 251, 252, EMAT 251, 252, 350. Advanced treatment of ceramic material including phase transformations, defect chemistry, thermodynamics, synthesis/processing, sintering theory, grain growth, and characterization. Emphasis is placed on functional properties of oxide ceramics for applications in energy conversion.

EMAT 553 ADVANCED COMPOSITE MATERIALS Even years, S 3 cr. LEC 3, PREREQUISITE: EMAT 463.

EMEC 444 MECHANICAL BEHAVIOR OF MATERIALS F alternate years, 3 cr. LEC 3, PREREQUISITE:

EMAT 251. THEORY, ANALYSIS, AND APPLICATION OF MECHANICAL BEHAVIOR OF MATERIALS. Constitutive behavior, plasticity, and fracture mechanics of engineering materials such as metals, polymers, ceramics and composites are analyzed. High temperature behaviors of materials are presented. Toughening mechanisms, fatigue, and damage tolerant design with modern engineering materials are emphasized.

EMEC 447 AIRCRAFT STRUCTURES On Demand 4 cr. LEC 3 RCT 1, PREREQUISITE: EMEC 341 or instructor approval. An introduction to the current practices in the design and analysis of aircraft metallic and composite structures. Overview of aircraft design, analysis, testing, and certification with examples. Static and dynamic load condition analysis.

EMEC 465 BIO-INSPIRED ENGINEERING F 3 cr. LEC 3, PREREQUISITE: EGEN 335, EMEC 320, EGEN 310 for majors; consent of instructor for non-majors. Addresses design in nature and resultant solutions as inspiration for solving engineering design problems. Structural, thermal, and fluid concepts in nature will be applied to engineering. Smart structures, self-healing materials, and robotics will be introduced.

EMEC 467 MICRO ELECTRO MECHANICAL SYSTEMS F 3 cr. LEC 2 LAB 1, PREREQUISITE: Senior standing; EELE 250 and EGEN 205; or consent of instructor. Introduction to sensors and actuators and their working principles. MEMS (microelectromechanical systems) fabrication procedures. MEMS Materials and their mechanical properties. Mechanical Behavior of Microsystems. MEMS Packaging and thermal-mechanical stresses in MEMS packages. Reliability Issues in MEMS.

EMEC 533 TRANSPORT PHENOMENA On Demand LEC 3, PREREQUISITE: EMEC 531. -- Comprehensive treatment of mass, momentum, and energy transport.

EMEC 565 SMART STRUCTURES On Demand 3 cr. LEC 3, PREREQUISITE: EMEC 303 and EMEC 342 and EMEC 445, or equivalent. Analysis and design of intelligent structures for aerospace, mechanical, and civil applications. Topics include piezoelectricity, shape memory effects, magnetorheology, and biomimicking.

PHSX 441 SOLID STATE PHYSICS F alternate years 3 cr. LEC 3, PREREQUISITE: PHSX 224. A treatment of the classification and electronic structure of solids. Properties of conductors, superconductors, insulators, and semiconductors will be discussed. This course is strongly recommended for students intending to study physics in graduate school.

PHSX 442 NOVEL MATERIALS FOR PHYSICS & ENGINEERING S alternate years, 3 cr. LEC 3, PREREQUISITE: Knowledge of introductory solid state physics; PHSX 441 or consent of instructor. Provides basic physical knowledge of advanced natural/artificial materials; ferroelectrics, superconductors, nanotubes, superlattices, photonics materials, materials with giant magnetoresistance and negative susceptibilities, molecular magnets, and biomaterials.

PHSX 515 ADVANCED TOPICS IN PHYSICS On Demand 3 cr. LEC 3 Maximum 6 cr., PREREQUISITE: Graduate standing. Topics in astrophysics, condensed matter physics, optics, mathematical physics, or particle physics are presented as needed to supplement the curriculum.

PHSX 516 EXPERIMENTAL PHYSICS F,S 3 cr. LAB 3 Maximum 6 cr., PREREQUISITE: PHSX 261, PHSX 423, and PHSX 461. Experiments chosen from laser optics and atomic, solid-state, and nuclear physics are carried out in depth to introduce the graduate student to methods, instrumentation, and data acquisition techniques useful for experimental thesis projects.

PHSX 544 CONDENSED MATTER PHYSICS I F alternate years, 3 cr. LEC 3, PREREQUISITE: PHSX 446,

PHSX 507. CRYSTAL STRUCTURE AND THE RECIPROCAL LATTICE. Quantum theory of electrons and phonons.

PHSX 545 CONDENSED MATTER PHYSICS II S alternate years, 3 cr. LEC 3 PREREQUISITE: PHSX 544. Applications to the transport, optical, dielectric, and magnetic properties of metals, semiconductors, and insulators.

MSU COURSES (Other):

On-line courses are under development.

APPENDIX IV – Benchmarking Study including PhD-Granting Institutions with MatSci and MS&E Programs

There are approximately 95 materials engineering and/or science doctoral programs in the United States and Canada that report to the American Society of Engineering Education's profile database. (The ratio of MS&E/MS doctoral programs in 2010 was 76/19 or about 4:1.) A summary of national enrollment and degree production as reported is shown in the following table:

Table IV.1: Selected Characteristics of National MS and MS&E Programs

		2005 – 2010	2010
BSc (MS and MS&E)	Enrollment		
	Degrees		1218
MSc (MS and MS&E)	Enrollment	1641	
	Degrees		772
PhD (MS only)	Enrollment	504	
	Degrees		53
PhD (MS&E only)	Enrollment	3569	
	Degrees		577

MS = Materials Science, MS&E = Materials Science & Engineering

One can be confident inferring from the table that not all BSc graduates continue to advanced degrees in the same discipline, which is true in engineering generally. This suggests one potential source of students for the proposed PhD program.

Furthermore, the Bureau of Labor Statistics projects a nominal 10% increase in the number of materials engineers and scientists will be needed by 2018 (3500 people). Assuming the existing MS/MS&E PhD programs are at steady-state or have a small additional capacity at most, the potential demand for a new PhD program, as we are proposing, is reasonable.

The table below considers programs in contiguous states:

Table IV.2: Selected Characteristics of Contiguous MS and MS&E Programs

		2005 – 2010	2010	Notes
North Dakota (No graduate program)	Enrollment			
	Degrees			
South Dakota (MSc/PhD at SDSM&T)	Enrollment	15 MSc/13 PhD		Materials Engineering & Science program
	Degrees		7 MSc/1 Phd	
Wyoming	Enrollment			

(No graduate program)	Degrees			
Idaho (Boise State and U. Idaho)	Enrollment	2 MSc/6 PhD		MS&E progams MSc only at Boise* MSc/PhD at U. Idaho
	Degrees		7 MSc/1 Phd	

* Boise State University will be starting a PhD in MS&E in the next year (http://www.idahostatesman.com/2011/05/05/1636406/micron-13-million-gift-is-boise.html

Expanding to the Rocky Mountain and Pacific Northwest regions:

Table IV.3. Selected Characteristics of Rocky Mountain and Pacific Northwest MS and MS&E Programs

		2005 – 2010	2010	Notes
U. .Washington	Enrollment	11 MSc/53 PhD		MS&E program
	Degrees		3 MSc/9 PhD	
Washington State	Enrollment	18 MSc/22 PhD		MS&E MSc program MS PhD program
	Degrees		3 MSc/4 Phd	
Oregon State	Enrollment	12 MSc/17 PhD		MS Program
	Degrees		9 MSc/2 PhD	
U. Utah	Enrollment	9 MSc/33 PhD		MS&E progam
	Degrees		2 MSc/4 Phd	
Colorado School of Mines	Enrollment	14 MSc/49 PhD		MS Program
	Degrees		0 PhD	

A review of the last two tables leads to several conclusions:

1. Two of the four states contiguous to Montana have no graduate programs in MS&E, while the remaining two programs have modest enrollments and degree production.
2. Two of the five Rocky Mountain programs are science-based and not MS&E.
3. Comparing MSU's potential to peer institutions Oregon State and Washington State, an average of three PhDs produced per year per campus does not seem unreasonable.

Based upon the above, an inter-institutional doctoral program in materials seems likely to be competitive and sustainable. As specific benchmarks, OSU and WSU seem reasonable choices, in particular since there is no dedicated MS or MS&E department at either institution. As reported to ASEE for 2010:

Oregon State University
Department offering degrees: Mechanical, Industrial, & Manufacturing Engineering
Tenurable faculty: 18
Research expenditures: $4.6M
Enrollments (FT and PT): 12 MSc MS, 17 PhD MS

Washington State University
Department offering degrees: Mechanical & Materials Engineering
Tenurable faculty: 23
Research expenditures: $2.7M
Enrollments (FT and PT): 18 MSc MS&E, 22 PhD MS

The proposed consortium of UM, MTech, and MSU compares favorably against these benchmarks.

U.S. Ph.D.-Granting Institutions with MatSci and MS&E Programs

University	E-mail Contact
Alfred University	dedwards@alfred.edu
Arizona State University	Jim.Adams@asu.edu
Auburn University	chengzh@eng.auburn.edu
Boise State University	darrylbutt@boisestate.edu
California Polytechnic State University, San Luis Obispo	tharding@calpoly.edu
Carnegie Mellon University	gr20@andrew.cmu.edu
Case University	jxc41@case.edu
Clemson University	luzinov@clemson.edu
Colorado School of Mines	mkaufman@mines.edu
Columbia University	Ji12@columbia.edu
Cornell University	epg2@cornell.edu
Drexel University	azavalia@coe.drexel.edu
Duke University	f.h.cocks@duke.edu
Georgia Tech	Bob.Snyder@mse.gatech.edu
Illinois Institute of Technology	yagoobi@iit.edu
Iowa State University	lesar@iastate.edu
John Hopkins University	Hkatz5@jhu.edu
Lehigh University	hmc0@lehigh.edu
Michigan State University	hawley@egr.msu.edu
Michigan Technological University	mrplich@mtu.edu
Missouri University of Science and Technology	huebner@mst.edu
Massachusetts Institute of Technology	elt@MIT.EDU
New Mexico Tech	mccoy@nmt.edu
Norfolk State University	cebonner@nsu.edu
North Carolina State University	Justin_Schwartz@ncsu.edu
North Western University	p-voorhees@northwestern.edu
Ohio State University	buchheit.8@osu.edu
Old Dominion University	RGregory@odu.edu
Penn State	messing@matse.psu.edu
Princeton University	cbarnold@princeton.edu
Purdue University	kbowman@ecn.purdue.edu
Rensselaer Polytechnic Institute	hullr2@rpi.edu
Rice University	ebarrera@rice.edu
Rutgers University	Danforth@rci.rutgers.edu
South Dakota School of Mines and Technology	jon.kellar@sdsmt.edu
San Jose State University	Michael.jennings@sjsu.edu
Stanford University	bobsinc@stanford.edu
Stevens Institute of Technology	hdu@stevens.edu
Stony Brook University	mdudley@notes.cc.sunysb.edu
Texas State University	tmyers@txstate.edu
University of Alabama	Vacoff@eng.ua.edu
University of Alabama at Birmingham	barry@uab.edu
University of Arizona	simmons@aml.arizona.edu
University of Buffalo	Ddlchung@buffalo.edu
University of California-Davis	rlpowell@ucdavis.edu

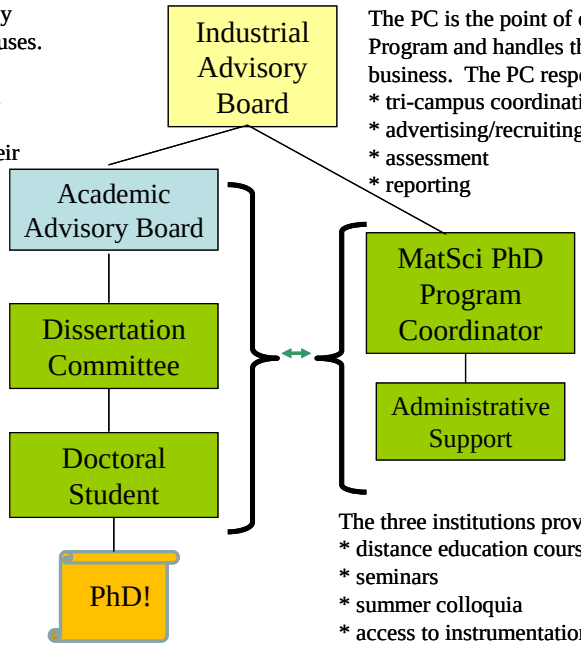
University of California-Irvine	sbgrant@uci.edu
University of California-Los Angeles	jyang@seas.ucla.edu
University of California-San Diego	vnesterenko@ucsd.edu
University of California-Santa Barbara	speck@mrl.ucsb.edu
University of Cincinnati	Raj.Singh@UC.edu
University of Connecticut	cbcarter@engr.uconn.edu
University of Dayton	Daniel.eylon@notes.udayton.edu
University of Delaware	milty@udel.edu
University of Florida	sphil@mse.ufl.edu
University of Illinois-Chicago	Fansari@uic.edu
University of Illinois at Urbana-Champaign	matse-head@illinois.edu
University of Kentucky	kalika@engr.uky.edu
University of Maryland	rbriber@eng.umd.edu
University of Michigan	pfgreen@umich.edu
University of Minnesota	bates@cems.umn.edu
University of Nebraska-Lincoln	jaturner@unl.edu
University of North Texas	reidy@unt.edu
University of Pennsylvania	davies@seas.upenn.edu
University of Pittsburgh	wiezorek@pitt.edu
University of Rochester	Jcl@me.rochester.edu
University of Southern California	tsotsis@usc.edu
University of Tennessee-Knoxville	pharr@utk.edu
University of Texas-Arlington	meletis@uta.edu
University of Texas-Austin	Drp@che.utexas.edu
University of Texas-Dallas	chabal@utdallas.edu
University of Texas-El Paso	lemurr@utep.edu
University of Utah	Anil.virkar@utah.edu
University of Virginia	wcj2c@virginia.edu
University of Washington	ajen@u.washington.edu
University of Wisconsin-Madison	babcock@engr.wisc.edu
University of Wisconsin-Milwaukee	hlopez@uwm.edu
Vanderbilt University	t.hanusa@vanderbilt.edu
Virginia Polytechnic Institute & State University	jluttrell@vatech.edu
Washington State University	dclark@vt.edu; zbib@wsu.edu
Wayne University	cmanke@eng.wayne.edu
Winona State University	babdelmagid@winona.edu
Worcester Polytechnic Institute	Sisson@wpi.edu
Wright University	george.huang@wright.edu
Yale University	mitchell.smooke@yale.edu

APPENDIX V – Program Administration Plan

U. Montana
MT/Tech
MSU

Conceptual MatSci PhD Administration and Organization

Academic Advisory Board would be made up of at least one MatSci faculty member from each of the three campuses. Their role would be oversight and guidance on matters such as Program policy. Each campus representative would have signature authority on their campus for, e.g.:
* Program of Study
* Prelim and comp exams



The Program Coordinator is a MatSci faculty member with some release, or other qualified professional with relevant technical and administrative experience. The PC is the point of contact for the Program and handles the day-to-day business. The PC responsibilities include:
* tri-campus coordination
* advertising/recruiting
* assessment
* reporting

Rather than prescribing a certain make up of the dissertation committee, the MatSci program provides opportunities for faculty from the three institutions to
* get acquainted
* collaborate
* jointly propose research
* team teach

The three institutions provide student's with
* distance education courses
* seminars
* summer colloquia
* access to instrumentation..

GT Solar Incorporated
110 E. Broadway, Ste. 400
Missoula, MT 59802, U.S.A.
Phone: 406 728 6200
Fax: 406 728 6230
E-Mail: info@gtsolar.com

September 29, 2009

Courtney Young
Department Head
Metallurgical and Material Science Engineering
Montana Tech of The University of Montana
1300 West Park Street
Butte, Montana 59701

Dear Courtney,

GT Solar is pleased to learn of your efforts toward the establishment of a Materials Science PhD Program at Montana Tech. We will support you, and the administration at Montana Tech and The University of Montana, in your endeavor to attain this tremendous program.

With my personal knowledge of the staff and facilities at Montana Tech, I can definitely recommend a Doctorate Level Degree within the Montana Tech Material Science Department. The quality of the students that Montana Tech attracts for the undergraduate and graduate programs, within the Metallurgical and Material Science Engineering Department, is certainly an indication of the quality of student that would be interested in a PhD program. The end result of this program will significantly benefit our local manufacturing industry.

In regards to GT Solar, we are continuously making improvements and expansions to our product line. In order for GT Solar to stay competitive in a worldwide market, we must design our equipment to be more productive and more economical to operate. Material of construction is an important factor in our efforts to achieve these goals. How well our equipment withstands the temperature, pressure, harsh environment, and other aspects of the associated processes, is vital to GT Solar's reputation as a global leader in the products and services for the Photovoltaic Industry. At the present time, GT Solar is involved in a working relationship with The Center for Advanced Mineral and Metallurgical Processing (CAMP) and Montana Tech. We believe that this relationship will be further enhanced with the introduction of a Materials Science PhD Program at Montana Tech.

Please consider GT Solar as an advocate for the Materials Science PhD Program at Montana Tech, and contact me if you need any assistance for this proposal.

Sincerely,

John J. Krstulich,
Principal Mechanical Engineer
GT Solar Incorporated

MicroPowder Solutions, LLC
1600 Sherwood Street
Missoula, MT 59802
Phone: 406-550-4647

To: Board of Regents
From: Dr. Yuval C. Avniel
Date: Tuesday, September 22, 2009
Re: Letter of support to establish a Materials Science PhD Program at Montana Tech.

Dear Sir or Madam:

My name is Yuval Avniel; I am president of MicroPowder Solutions, LLC. which is an advanced materials development company. As a company we supply technical solutions to the advanced materials marketplace, technical due diligence and intellectual property development. It is our understanding that Professor Courtney Young of Montana Tech is in the process of establishing a Ph.D. program at Montana Tech. We believe that this program would add significant value to the state, Montana Tech and the industry at large. Material science as a discipline is rapidly becoming of primary importance across a wide spectrum of industries. At the present the industry is in need of skilled personal and all forecasts predict this need to increase. We believe that Prof. Young could help meet this need if the proposed Ph.D program was established.

We at MicroPowder Solutions, LLC. support Professor Young's pursuance of a Ph.D. program and look forward to working with both Prof. Young and his students on future projects.

Thank you for your time and consideration,

Yuval

Yuval Avniel, Ph.D.
MicroPowder Solutions, LLC.
1600 Sherwood Street

Technology Applications, Inc. 200 Technology Way, P.O. Box 4078 Butte, MT 59702 406.494.7100
www.mse-ta.com

Engineering Solutions

September 14, 2009

Montana Board of Regents
Office of Commissioner of Higher Education
Montana University System
2500 Broadway Street
PO Box 203201
Helena, MT 59620-3201

I am writing to ask your support for a joint Materials Science Doctorate Program between The University of Montana – Missoula and Montana Tech. As a Tech graduate, I am keenly aware of the value and recognition a degree from Montana Tech generates. Montana Tech is part of a small group of natural resource based academic institutions recognized for their excellence in the field and the only one without a doctorate program.

As President of MSE Technology Applications, Inc., an engineering and technology company headquartered in Butte, I also strongly support the addition of a Materials Science Doctorate Program. Many MSE employees have pursued continued education through the Masters Degree level at Montana Tech but go no further due to lack of doctorate programs in our area. For those employees committed to doctorate level education, we would support their continued academic endeavors because in the long run it will benefit MSE.

The addition of a Materials Science doctorate program appears to have only upside benefits including: raising the stature of Montana Tech to the level of its peer institutions and providing a resource for engineering, science, and technology based companies in Butte and southwest Montana.

A Materials Science Doctorate Program would allow Montana Tech and The University of Montana to significantly expand its research program, thereby providing more research grant funding for The University of Montana System. Such an expansion would enhance Montana Tech's ability to attract nationally- and internationally-recognized faculty and research scientists to The University of Montana System resulting in further expansion of research activities and revenues, increased recognition and prestige, and potential technology transfer and commercialization opportunities.

I hope you will consider the establishment of a Materials Science Doctorate Program. I would be happy to provide support in any way possible.

Sincerely,

Jeffrey W. Ruffner, P.E.
President & CEO

JWR/jz

MONTANA ENVIROMET, INC
1600 Blacktail Loop
Butte, MT 59701
August 3, 2012

Courtney Young
Dept Head and ASARCO Professor
Metallurgical & Materials Engineering Department
208A ELC Building
1300 West Park Street
Montana Tech
Butte MT 59701

Re: Proposed Doctorate Program in Materials Science and Materials Engineering

Dr. Courtney Young:

It is my pleasure to write this letter in support of the proposed doctorate program. I am well aware of the proposed program goals and the need for the program in Montana as stated in your proposal quoted below. Montana Enviromet enthusiastically supports the proposed degree request.

> "*Montana is experiencing sustained growth in the highly competitive materials industry. Scientists and engineers at existing operations in Butte (MSE-TA, REC Silicon, Resodyne, Polymeric Interconnect, BIFS Technology, Montana Enviromet and SeaCast which is under construction), Anaconda (AFFCO), Helena (American ChemMet), Missoula (MicroPowder Solutions LLC and PSI), Bozeman (Federal Technology Group) and Kalispell (Semitool) as well as research facilities (MSE Technology Applications, Inc., Resodyne, and Allihies Engineering) must extensively apply Materials Science and Engineering principles to succeed in business. The proposed program will focus on industrial needs, research and issues, in particular, those which are of direct benefit to Montana industries.*
>
> *No doctoral level Materials Science or Materials Engineering programs exist in Montana, and only two such programs are available in the contiguous states (at the University of Idaho and at South Dakota School of Mines and Technology, respectively). Consequently, students within the Montana University System who wish to pursue doctoral studies in this field are forced to continue their education outside of the state. Implementation of the proposed doctoral program will enable these students to pursue their studies within the Montana University System and, additionally, attract qualified graduate students from other parts of the nation and world." (From proposal to State Board of Reagents, 2009)*

Montana Enviromet would be pleased to partner with the Montana University System in supporting research and potentially employing graduates from the Materials Science and Materials Engineering program.

L. G. Twidwell

Dr. L. Twidwell, President
Montana Enviromet, INC
(406)494-1576; (406)560-2263 (Cell)

Polymeric Interconnect

***8 South** Montana Street*

Butte Montana, 59701

Hugh Craig
Polymeric Interconnect Inc.
8 S. Montana Street
Butte, Montana 59701

Dr. Courtney Young
Department Head
Metallurgy and Materials
Montana Tech
University of Montana

Dear Dr. Young

I am writing to endorse the creation of the Doctorate Program in Materials Science at Montana Tech. It is readily apparent that Materials Engineering and Science is rapidly becoming the singular most important scientific discipline for tomorrow's technology. Nanotechnology will be a game changer, and the importance of Montana's Universities to realize this and participate in this discipline is paramount for Montana's economic development through the next decades.

My company is engaged in product development for the US Renewable Energy sector. Energy solutions will come from Materials research and development, particularly those that are related to nanotechnology. It will, of course, be a great resource for us to have this program at Montana Tech. Polymeric Interconnect is available to assist you in any way that we can in this endeavor.

Sincerely,
Hugh Craig
President

REC Silicon
119140 Rick Jones Way
Silver Bow, MT 59750
Tel: (406)496-9898 Fax: (406)496-9801
www.recgroup.com

September 24, 2009

Courtney Young
Department Head
Metallurgical and Material Science Engineering
Montana Tech of the University of Montana
730 West Park Street
Butte, MT 59701

Dear Courtney,

REC Silicon is very supportive of your efforts and the efforts of the other administrators at Montana Tech and the University of Montana toward securing a doctorate degree at the College in Materials Science Engineering.

This degree is one that our company, REC Silicon, has tremendous interest. The product that we produce, polycrystalline silicon is not completely defined. We feel that the implementation of this degree will provide an opportunity for our material to be better understood. The ability of the college to provide a quality education, characteristic of Montana Tech, quality graduates that will be available for employment by companies such as ours and research of materials used in our line of business is something that truly excites REC Silicon.

The technology that we employ at REC Silicon both at our Silverbow, MT facility, just west of Butte, and at our soon to be three facilities in Moses Lake, WA has very special needs with regard to materials of construction to maintain our operation and the quality of our product. These requirements have us constantly looking at our materials of construction for better and more economical ways of handling our feed stocks and products. Having the kind of expertise that you will provide, at our finger tips, will be an extremely advantageous position for us.

Please place REC Silicon on the list of favorites for this motion to proceed and also let us know what we can do to assist in making this happen.

With Kind Regards and Support in the Future,

REC Silicon

Brian Sullivan,
Silverbow, MT Plant Engineering Manager

REC Silicon
119140 Rick Jones Way
Silver Bow, MT 59750
Tel: (406)496-9898 Fax: (406)496-9801
www.recgroup.com

September 24, 2009

Courtney Young
Department Head
Metallurgical and Material Science Engineering
Montana Tech of the University of Montana
730 West Park Street
Butte, MT 59701

Dear Courtney,

As the Chairman of the Industrial Advisory Board for the Metallurgical and Material Sciences Engineering Department at Montana Tech, I will take the liberty to express the board's unanimous support of you and other administrators at Montana Tech in your endeavors to establish a Doctorate Level Degree within your department in Materials Science Engineering.

Having worked with you and the department for the past six (6) years I am very confident that the efforts that you are putting forth are in earnest and are for the betterment of the student at the college, along with the betterment of the college and the sciences involved. In my tenure as Chairman, you and your colleagues' devotion to the students at Montana Tech has always shown through and the efforts to establish this degree is yet an extension of that character.

Materials Science Engineering is an enormous part of the work that I and my colleagues here at REC Silicon and in an ever increasing number of other industries. As new technologies are devised and implemented to meet the needs of mankind the engineer must always be looking at the materials of construction that are employed to contain and produce these products. Expertise, like that which you will nurture with this degree, will be forever needed in this world. The success of this degree will be unquestionably high, in my humble opinion.

You can look to your Industrial Advisory Board for any support that you may need in this venture. Good luck and please do not hesitate to contact me, as always, if you need further assistance in this matter.

Kind Regards,

Thomas F. McIntyre,
Industrial Advisory Board Chairman – Metallurgical and Materials Science Engineering
Montana Tech of the University of Montana and REC Silicon Construction Manager / Senior Processing Engineer, Silverbow, MT Plant

Resodyn CORPORATION

Building Value through Discovery & Innovation

September 15, 2009

Dr. Courtney Young
Montana Tech
Department Metallurgy and Materials Engineering
208A ELC Building
1300 West Park Street
Butte, MT 59701

Dear Dr. Young:

Resodyn Corporation is a strong supporter of higher education and advanced degrees from the Montana higher education system. As you are aware, the work conducted at Resodyn Corporation conducts, requires staff with advanced degrees and across a broad spectrum of disciplines. In fact, our success in attracting a significant amount of funding from the Small Business Innovation Research program (100 awards, resulting in more than $22,000,000 in funding) over the past several years has been made possible by the strong educational background of our staff, which includes seven PhD, five Masters of Science and three Masters of Business Administration degrees.

In addition to the staff that we bring on board with these advanced degrees, Resodyn Corporation supports exiting staff to advance their education, most notably, we are providing full financial support for a full time Resodyn Corporation employee to obtain a PhD in Mechanical Engineering at MSU. (This person, a Montana native, obtained a BSME from MSU and a MSME from Montana Tech.)

Since having advanced degreed staff is so important to the development and growth of Resodyn Corporation, we see tremendous benefit to our business for Montana Tech to establish a PhD program in Butte. If this occurs, you can be assured that Resodyn Corporation would be a strong supporter of the program, by working with factuality to bring in research grants, support graduate interns and to be an eager source of employment for PhD graduates from Montana Tech.

A Materials Science PhD program at Montana Tech would fit well into our continued efforts to develop new R&D programs and to produce products that we can manufacture and sell which are natural resource-based and are of value to the environment.

In addition to the direct benefit of having a PhD program as a new level of achievement, the inclusion of Montana Tech PhD program will result in attracting better students and faculty, as well as provide Montana Tech to be more competitive for research grant funding.

Having a PhD program at Montana Tech appears to be a win-win for students, faculty, the Montana higher education system, businesses in Montana, for the community of Butte and surrounding areas. There certainly seems no real downside to placing a new PhD program at Montana Tech and there are certainly a litany of upside scenarios for all.

Please consider the importance of approaching the Board of Regents for the installation of a PhD program at Montana Tech. Needless to day, you can count on our strong support in aggressively taking this initiative forward.

If you would like additional input from us, or have any questions on our position, please contact us and we will be happy to address them.

Respectfully,

Lawrence C. Farrar, P.E.
President

130 N. Main Street, Suite 600 Butte, Montana - 59701 (406) 497-5252

Zinc Air Inc.

215 Browns Gulch Rd
Kalispell, MT 59901

Phone: (406) 250-6553
Fax: (509) 463-3994

September 18, 2009

Courtney Young
Dept Head and ASARCO Professor
Metallurgical & Materials Engineering
208A ELC Building
1300 West Park Street
Montana Tech
Butte MT 59701

Courtney,

Thank you for taking the time to meet with us yesterday. I was very impressed with the application based research Montana Tech can provide Zinc Air, and I am very interested in pursuing research opportunities with you. I was also very interested in your desire to provide a PhD Program in Materials Science.

As we discussed, Zinc Air is developing a grid storage battery technology with Semitool and we will extensively apply Materials Science and Engineering principles in the ongoing development and our technology. The ability to work with Montana Tech would expedite our development due to their close proximity and the need for extensive R&D projects we are planning in the near future. By closely working with the University and their students, we will have a ready-made workforce that is already familiar with our technology.

In addition to the grid storage battery, Zinc Air is working on several other renewable technologies that would benefit from a PhD program in Materials Science at Montana Tech. As Montana's economy evolves, it is important that our educational systems evolve as well. I believe this is a critical step in the right direction and I would be happy to support this effort in any way possible.

I wish you success in this endeavor.

Vice President
Zinc Air, Inc.
215 Browns Gulch Rd.
Kalispell, MT 59901

BENTLEY CONSTRUCTION COMPANY

Building a better tomorrow...

3701 Warren Avenue – P.O. Box 3646
Butte, MT 59702

Phone: 406-494-4501 * Fax: 406-494-4519

E-mail: info@bentleyconst.com
www.bentleyconst.com

July 30, 2012

Dr. Donald Blackketter
Chancellor, Montana Tech
1300 West Park
Butte, MT 59701

Dear Don:

Bentley Construction Company, Inc. has always been a strong supporter of higher education in Montana, and from Montana Tech in particular. We are writing to offer our encouragement to your endeavors to establish a Doctorate Level Degree at Montana Tech.

We are a family owned and operated business in Butte, and are proud to claim that our current operating officers are alumni of the college. As Tech graduates we are aware of the value and the recognition that a degree from Montana Tech offers in the business world. Unfortunately, the size of our business and the market in which we operate would not allow for us to utilize graduates at this level, but we understand that if Montana Tech were to offer doctorate engineering degrees, in addition to graduating top-notch employees for the businesses who recruit from the college, you would definitely gain more recognition and respect as a research facility.

We believe that if Montana Tech were to offer a doctorate program, the ability to attract faculty and researchers to our area would be greatly enhanced, which in turn would potentially increase commercialization in our area. This program is a definite win-win situation for the college and community.

We sincerely support the establishment of a Doctorate program at Montana Tech.

Sincerely,

Robert D. Bentley

Robert D. Bentley
President

Butte Local Development Corporation

July 24, 2012

Dr. Donald Blackketter
Montana Tech
1300 W. Park ST
Butte, MT 59701

Dear Chancellor Blackketter;

I am writing this letter on behalf of the Butte Local Development Corporation (BLDC) to express our support for PhD degree in Material Science between Montana Tech, University of Montana and Montana State University.

It is very encouraging to see three units of the Montana University System cooperating for a doctoria degree that will provide great benefits for Montana. As a result of this new advanced degree there will be increased funded research that will take place on all three campuses. This new influx of mone will provide a boost to each of the local economies and hopefully additional employment opportunities for our college graduates.

It is a proven fact that strong university research program can spin off many new businesses that can provide a great impetus for economic growth on a local and statewide basis. Massachusetts Institute of Technology's research is the largest generator of new jobs in the state of Massachusetts. Both Missoula and Bozeman are homes of new technology based companies that grew out of the university's research and graduate programs. Butte too will benefit greatly with the addition of this new curriculum through Montana Tech.

Montana Tech has long been a nationally recognized educational institution for undergraduate engineering graduates. The expansion of the Tech's graduate school is long overdue. The lack of the ability to grant a PhD degree has limited Tech growth possibilities. With this new degree program in place Montana Tech growth potential can be achieved.

The BLDC is the designated lead economic development entity for Butte-Silver Bow. We have always considered Montana Tech as an integral part of our local economy and one of the sectors that has a huge potential for expansion. The BLDC wholeheartedly support the granting of a joint PhD degree i Material Science between Montana Tech, University of Montana and Montana State University.

Thank you in advance for your support for this proposal.

Sincerely,

Jim Smitham
Executive Director

480 East Park St. - PO Box 507 - Butte, Montana 59703
(406) 723-4349 - fax (406) 723-1539 - www.buttemontana.org

BUTTE-SILVER BOW
OFFICE OF THE CHIEF EXECUTIVE
Courthouse, 155 W. Granite Street, Suite 106
Butte, Montana 59701-9256

August 3, 2012

Dr. Don Blackketter
Chancellor
Montana Tech
1300 West Park Street
Butte, MT 59701

Dear Dr. Blackketter:

It is an honor and a privilege for me, as a Montana Tech graduate and now as the Chief Executive of the Butte-Silver Bow local government, to write this letter of support as you pursue a Ph.D., program in Materials Science (MatSci) Materials Science and Engineering (MS&E). I can only imagine the possibilities that will be realized when Montana Tech, the University of Montana - Missoula, and Montana State University – Bozeman collaborate on this doctoral program.

As you know, our community is rapidly gaining national and international recognition because of the innovative environmental and high-tech firms that have chosen Butte for their operations, and because Montana Tech has a worldwide reputation for excellence. I believe many of Butte's engineering, environmental, and high-tech firms such as AeroTec, DOWL HKM, MSE, Montana Enviromet INC, Pioneer Technical Services, Polymeric Interconnect, REC, Resodyn, SeaCast, and Water & Environmental Technologies and others would be greatly served by this program.

Our state and local economies can only benefit from the MatSci Ph.D., program that will attract additional entrepreneurial enterprises to further our local and state economies. This is an incredible opportunity for all of Montana, especially, southwest Montana.

Please let me know how Butte-Silver Bow can partner with you to accomplish this goal. Please call me at (406) 497-6221 or email me at chiefexec@bsb.mt.gov. Thank you for all of your hard work in pursuing this worthwhile program.

Sincerely,

Paul David Babb
Chief Executive

Marko Lucich, Executive Director
1000 George St.
Butte, MT 59701
Ph: (406) 723-3177 Fax: (406) 723-1215

July 29, 2012

Dr. Donald Blackketter
1300 W. Park Street
Butte, MT 59701

Re: Proposed Material Science PhD Program

Dear Dr. Blackketter:

On behalf of the approximate 400 members of the Butte-Silver Bow Chamber of Commerce, I am writing this letter in strong support of the proposed Material Science PhD program at Montana Tech. A quick evaluation of major companies in the Butte area and western Montana that are in dire need of doctorial candidates in this field for the sustainability and expansion of their companies is evidence in itself that the Material Science PhD at Montana Tech is warranted and needed.

As our economic team consisting of the Butte Chamber, the Chief Executive and the Executive Director of Butte Local Development meet with major employers of existing businesses and potential new businesses who are in need of this specialty, the lack of a PhD program remains a major concern for retaining existing firms and attracting new firms. Needless to say, the addition of a Material Science PhD is of vital importance to Butte and Southwest Montana.

In closing, the Butte-Silver Bow Chamber of Commerce sees this as a critical step in the right direction for education, research, employment and an enhancement to Montana Tech of an already outstanding institution. If the Chamber can be of any further assistance, please do not hesitate to contact me. Thank you for your time and consideration.

Sincerely,

Marko Lucich

Marko Lucich
Executive Director
Butte-Silver Bow Chamber of Commerce

CLOUD PEAK ENERGY®

Gary S. Rivenes
Executive Vice President and Chief Operating Officer

July 26, 2012

Dr. Donald Blackketter
Montana Tech
1300 W. Park ST
Butte, MT 59701

Dear Dr. Blackketter:

Cloud Peak Energy is a strong supporter of both higher education and the Montana University System. We have significant and complex assets in our business and understand the benefits of advancing the materials science field to increase the reliability and longevity of these mining assets. Consequently, we are excited to support your efforts to secure a Ph.D. program in Materials Science and Engineering.

This program will allow the University of Montana, Montana Tech and Montana State University to collaborate resources. An effort we believe will both unify the endeavour and the campuses. Additionally, it will provide a significant avenue to attract and retain national and international talent to Montana as well as increase funding for research in this critical and growing field. Creating another option for students to continue their education at a school as valued in industry as Montana Tech is admirable.

As the Executive Vice President and Chief Operations Officer, the field of Material Science also plays a critical role in ensuring the safety of our employees. We rely daily on a host of devices from shock absorbing lanyards to programmable logic controllers. I feel that advances in technology involving the material science area has definitely helped us achieve one of the best safety records in the industry, and I look forward to the future advances to further our cause.

Please relay on our strong support for this program to the Board of Regents, and if you need additional input from me, or have any questions about our level of support for this program please do not hesitate to ask.

Sincerely,

Gary Rivenes

CLOUD PEAK ENERGY RESOURCES LLC | 505 South Gillette Avenue (82716) | PO Box 3009 | Gillette, WY 82717-3009
T+1 307 687 6000 | F+1 307 687 6015 | www.cloudpeakenergy.com

Nelson, Carmen

From: Young, Courtney
Sent: Monday, July 30, 2012 4:17 PM
To: Nelson, Carmen
Subject: FW: Ph.D. program in Materials Science

FYI

From: Tom Russell [mailto:t.russell@emissionresourcegroup.com]
Sent: Monday, July 30, 2012 4:16 PM
To: ed.rosenberg@umontana.edu; cjenkins@me.montana.edu
Cc: Young, Courtney
Subject: Ph.D. program in Materials Science

Emission Resource Group, LLC

"Assuring Our Nation's Energy Security as We Transition to a New Energy Future"

Gentlemen,

Today it was brought to my attention of the request being proposed for the Ph.D Program in Material Science. Our firm has witnessed firsthand the need for this exact program. In the ever changing environment of the world, to maintain our competitive advantage we must be on the forefront of new technology or scientific processes. Montana Tech of The University of Montana is one of the leaders in their field. We believe that if provided the proper equipment and resources (such as this program), processes they have developed could have been implemented today. As a corporation working with algae, coal, and CO2 recovery from Coal Fired Power Plants around the world, we could benefit from the fruits of this type of program. Please let me know what, who, and when we can help support this program. We also understand that the PhD is to be collaboration with UM-Missoula and MSU-Bozeman. This is wonderful, because it will open the doors even further. We look forward to strengthening our relationships in this regard.

Thomas Russell, PE
Chief Executive Officer

PO Box 411, Seahurst, WA 98062
206-673-2270 Ext. 101
e-mail: t.russell@emissionresourcegroup.com

Hecla Greens Creek Mining Company
P.O. Box 32199
Juneau, Alaska 99803

August 2, 2012

Dr. Donald Blackketter
Montana Tech
1300 W Park ST
Butte, MT 59701

RE: Support for PhD Program in Materials Science

Dear Dr. Blackketer

It is my pleasure to write a letter supporting the establishment of a PhD program in Materials Science at Montana Tech.

Hecla Greens Creek Mining Company has employed a number of Montana Tech interns and graduates over the years, in disciplines including mine engineering, geology and metallurgy. We maintain an active scholarship program with the Montana Tech Foundation and frequently attend career events hosted by the University.

Any program that attracts and retains quality students and research in support of those seeking to establish productive and rewarding careers in extractive metallurgy is of interest and value to Hecla, the mining industry and the community at large.

Please let me know if I can provide additional information.

Sincerely,

Ron Plantz
HR & Community Relations Manager

MADA
MONTANA AEROSPACE
DEVELOPMENT ASSOCIATION

July 30, 2012

Dr. Don Blackketter, Chancellor
Office of the Chancellor
1300 W. Park Street, MG 301
Montana Tech of The University of Montana
Butte MT 59701

Dear Dr. Blackketter:

This letter is to inform you that the Montana Aerospace Development Association (MADA) strongly supports the PhD in Materials Science Degree that is being proposed by Montana Tech, the University of Montana, and Montana State University. MADA is a non-profit technology advocacy and economic development organization, whose mission is to support the State of Montana's initiative to make both aerospace and advanced energy technology-related enterprises a significant component of Montana's economy. MADA is a state-wide organization with representation from the State of Montana; Montana Congressional Delegation; Montana University System; Montana economic development community; Cities of Butte, Great Falls, and Billings; and private-sector. We perform our mission by supporting the recruitment of aerospace and advanced energy technology-related businesses to Montana, identifying new business opportunities for Montana's aerospace and advanced energy technology community, facilitating partnerships, sponsoring conferences and workshops, advising policy-makers, and recommending new educational and workforce training programs. Additionally, MADA manages and operates the Butte AeroTec Facility, which is a new low-cost/user-friendly aerospace and advanced energy technology test and evaluation center located near Butte, Montana.

Materials science is very important to the aerospace and advanced energy technology industries, and MADA believes that the proposed PhD Degree will significantly facilitate our efforts. Additionally, we believe that the program's joint/multi-campus feature will provide for maximum leveraging of the unique strengths of each of Montana's science and engineering institutions and make the program much more accessible to Montana's working professionals. As such, it is our opinion that this innovate approach to the Degree will provide Montana's aerospace and advanced energy technology communities with a unique educational opportunity in a very efficient and cost-effective manner.

MADA looks forward to supporting Montana Tech, the University of Montana, and Montana State University with the development of the new PhD in Materials Science Degree, as well as exploring ways in which we can collaborate with the program for the mutual benefit of the entire State.

Sincerely;

David A. Micheletti
Chairman, Board of Directors

65 E. Broadway Street, Butte, MT 59701 406 490-1395 406 533-6830 fax Website: www.montanaaerospace.org

Newmont Mining Corporation
6363 South Fiddler's Green Circle, Suite 800
Greenwood Village, CO 80111
T 303.863.7414
F 303.837.5837
www.newmont.com

May 21, 2012

Donald M. Blackketter
Chancellor, Montana Tech of The University of Montana
Montana Tech
1300 W. Park St.
Butte, Montana 59701

Dear Mr. Blackketter,

I hope this letter finds you well after the completion of your first academic year at Montana Tech.

Following our meeting of 23 April 2012, I would like to reiterate that Newmont Mining Corporation has a long history of association and support for Montana Tech. Montana Tech is one of Newmont's key partners in supplying mineral science graduates necessary for the mining industry and Montana Tech Alumni are well represented at Newmont. Newmont has also been supportive in providing projects and funding for graduate students at Montana Tech (especially in the Metallurgical & Materials Engineering and Mine Engineering areas) in addition to scholarship funding, salary support for faculty, and general department support. Newmont Mining Corporation will continue to support graduate student projects and research that is beneficial to both Montana Tech and Newmont.

Sincerely,

Scott D. Rosenthal
(Alum 1982 & 2010, Executive Sponsor for Montana Tech at Newmont Mining Corporation)
Senior Director, Mine Engineering
Solutions & Innovation, Operations & Projects

Cc: Brooke Bacon, SR University Strategy Manager, Human Resources
Sheri Snyder, University Specialist, Talent Acquisition

Peter J. Simonich
Vice President and C.O.O.

PPL Montana, LLC
303 N. Broadway, Suite 400
Billings, MT 59101
Tel. 406.237.6900 Fax 406.237.6901
pjsimonich@pplweb.com

July 30, 2012

Dr. Donald Blackketter
Montana Tech
1300 W. Park ST
Butte, MT 59701

Dear Dr. Blackketter:

I am writing to inform you of PPL Montana's support for the proposed Materials Science Doctorate Program to be established between Montana Tech, The University of Montana – Missoula, and Montana State University – Bozeman.

Offering a Materials Science Doctorate program in the Montana University System will bring valuable opportunities to students. Additionally, the importance of researching & developing new and better materials is important to Montana's economy. Materials Science research could lead directly to enhancing the competitiveness of Montana businesses including PPL Montana's operations.

The benefits of the proposed Doctoral program to Montana are numerous. PPL Montana encourages a timely approval of this proposed doctoral program. Thank you for considering PPL Montana's viewpoint on this matter.

Sincerely,

Peter J. Simonich
Vice President & COO

cc: David Hoffman
Lisa Perry
Mark Zora

Rare Element

August 3, 2012

Dr. Don Blackketter, Chancellor
Office of the Chancellor
1300 W. Park Street, MG 301
Montana Tech of The University of Montana
Butte MT 59701

Dear Dr. Blackketter:

I am writing to support the creation of a doctoral program in Material Science at Montana Tech. Early last month, Congressman Amodei introduced House Bill 4402, The National Strategic and Critical Mineral Production Act, which outlines a strategy to more efficiently develop domestic sources of these minerals. This Bill supports the recommendations by the National Academies of Sciences that the US needs reduce its' dependence on foreign sources of these minerals. This includes the strategic need to expeditiously develop Rare Earth resources and reduce our dependence on Chinese imports.

As you know there is a general lack of qualified engineering and scientists in the United States and this become even more evident during times like this where we need to expedite our development of critical materials. Rare Element Resources is currently developing one of the largest domestic deposits located in Crook County, Wyoming. The Bear Lodge Project will become the third largest Rare Earth mine in North America. Recently, we completed an exhaustive search to find a PhD Scientist to support our project. We were unable to find any candidates in the United States and ended up hiring a scientist from Europe. We are currently supporting a Metallurgical Engineering student at Montana Tech with the hope that she will be able to continue on to obtaining a PhD.

A Materials Science doctoral program at Montana Tech would serve to help fill this gap in qualified scientists and support the development of critical materials in the United States.

Please let me know how we can provide addition support in the development of this program.

Sincerely,

Jaye T. Pickarts, PE
Chief Operating Officer

225 Union Blvd, Suite 250
Lakewood, CO 80228
Tel: 720.278.2460
Fax: 720.278.2490

ROVIG MINERALS, INC.
2812 FIRST AVENUE NORTH, SUITE 510
BILLINGS, MONTANA 59101

July 25, 2012

Dr. Donald Blackketter, Chancellor
Montana Tech
1300 W. Park Street
Butte, MT 59701

Dear Dr. Blackketter:

I would like to offer my total support for the proposed Ph.D. program in Materials Science. I am a 1964 graduate of Montana School of Mines in Mining Engineering and after nearly 50 years in the mining business I can assure that I have a great appreciation for the role and necessity of properly handling all aspects of materials science and engineering in the natural resource industries. From the very basic (ore/coal handling and transportation) to the exotic and developing components of the nations high tech applications I see the need to advance our materials science capabilities.

The proposed program would be a natural progression in Tech's already impressive engineering programs and it would clearly enhance its stature in state, national, and international venues.

Good luck on this endeavor and please let me know if there is any way that I can help.

David B. Rovig, President
Rovig Minerals, Inc.

406 245 9520 off 406 698 7844 cell
rovigminerals@imt.net

SEACAST
Precision Investment Castings

August 7, 2012

Dr. Donald Blackketter
1300 W. Park ST
Butte, MT 59701

Dear Dr. Blacketter,

This letter is to voice SeaCast's support of the Material Science PhD Program that is being considered for the Butte campus.

SeaCast supplies investment castings internationally from four US-based manufacturing sites. Two years ago we opened a new manufacturing facility in Butte, where we will be pouring a wide variety of alloys (including titanium and superalloys) for the aerospace and high-end commercial markets. The processes and materials that are used in the manufacture of our products in Butte are technologically advanced and in some cases cutting edge. One of the many things that attracted us to put the new plant in Butte is the easy access to the graduates of your engineering schools, as well as access to the present (and future) research capabilities offered by your metals-related engineering departments. Having the PhD program in Material Science would be a major boost to these capabilities.

SeaCast is at the forefront of investment casting foundries in the US, and our intent is to make the Butte facility a major strategic supplier to the aerospace industry. We envision many projects and collaborations that could utilize the capabilities of this PhD program.

In addition, the titanium processing capabilities at this plant provide a fertile soil for potential developments by the PhD researchers. Both the aerospace and defense industries realize that titanium materials are strategic to a competitive and secure future.

Hence, we would be very excited to see this program come to Tech.

Sincerely,

Bert Robins
Vice President

6130 31st Avenue NE. Marysville. Washington. 98271 • 360.653.9388 • 360.653.6044 Fax

July 30, 2012

Dr. Don Blackketter

Chancellor

Montana Tech

1300 West Park Street

Butte, Montana 59701

Dear Dr. Blackketter:

It is an honor for me to write this letter supporting the requested PhD Program in Materials Science offered by Montana Tech, Butte, UM, Missoula and MSU, Bozeman. Montana Tech as well as UM and MSU are autonomous institutions as to their accreditation by the NWCCU thus giving them the ability to offer advanced degrees in their core competencies. The Commission will view this PhD Program as the normal progression and growth of an institution.

Montana Tech has an excellent international reputation in Natural Resource Education. All of Montana Tech's peers in the Natural Resource Engineering arena have doctoral programs. Collaboration of Montana Tech, UM and MSU in regard to this PhD Program will strengthen research on all three University Campuses and should be viewed as a wise use of resources.

Remember going forward, the Montana University System relies on their customers to exist. Those customers are the students seeking to enhance their lives through furthering their education by attending a University in Montana of their choice. Their research in math, science, and engineering is in and of itself a small industry and drives economic development.

Thank you for giving me this opportunity to share my thoughts with you and the decision makers on this very important matter.

Sincerely,

Margie M. Thompson

3505 Quincy St., Butte, Montana 59701

Former Chairwoman, Board of Regents, State of Montana

Former NWCCU Commission Member

Ueland Family Limited Partnership

July 30, 2012

Dr. Donald Blackketter
Montana Tech
1300 W. Park Street
Butte, Montana 59701

Dear Dr. Blackketter:

I am writing to you in support of your efforts to secure a Materials Science PhD. Program for Montana Tech in Butte.
As you may know, I represent SeaCast, Inc. and Intercontinental Truck Body, both defense contractors and both are in need of materials expertise here in Montana. This PhD program will greatly bridge the gap between private industry and academia, as it will connect the research base more with what the world needs in material science.
This will rightfully allow many candidates to learn and produce right here in Montana, and also it will allow Montana Tech to offer programs that will allow Tech to reach its potential along with its students.

This needs to be done!

Respectfully,

Ron Ueland

8 West Park Street, Ste 210 Butte, MT 59701 Phone: 406-782-4670
Fax : 406-782-5332

WATER & ENVIRONMENTAL TECHNOLOGIES

Consulting Scientists & Engineers
480 East Park Street, Butte MT 59701
(406)782-5220

July 30, 2012

Dr. Donald Blackketter
Montana Tech
1300 W. Park ST
Butte, MT 59701

RE: Strong Support for Material Science PhD Program at Montana Tech

Dear Dr. Blackketter,

I would like to voice my strong support for the PhD program at Montana Tech from the standpoint of an alumnus, the owner of an engineering consulting business, and a parent of engineering students.

With respect to my status as an alumnus, the next logical step for Montana Tech is to offer advanced education in several degree programs and this is the perfect first step. Tech has the Professors to provide the curriculum, and relationships with the industries to provide both research and employment opportunities. The addition of the doctorate program at Montana Tech would open doors for students and staff alike; thereby, benefiting the institutions reputation and providing an additional avenue for growth.

Montana Tech also attracts the type of students required to pursue advanced degrees. Many of the students go on to obtain doctorates from other institutions. As a parent, my daughter has left Montana Tech to pursue a doctorate in Material Science at the University of Washington. This represents three lost opportunities for Montana Tech: 1. a loss of talented students, 2. a loss of research opportunities, and 3. a loss of potential Professors as future staff. These items should be incentive enough to offer a doctorate program.

As the owner of an engineering consulting company in a competitive market, resumes and experience make the difference in our ability to procure challenging projects and provide qualified professionals. I strongly support the addition of a Material Science PhD program at Montana Tech and of additional PhD programs in the near future. In moving forward, I offer my support for the program and Montana Tech.

Sincerely,
Water & Environmental Technologies

David J. Erickson, PG
President/Principal

2933 Burke Lane
Butte, MT 59701

July 24, 2012

Montana Board of Regents
Office of Commissioner of Higher Education
Montana University System
2500 Broadway Street
PO Box 203201
Helena, MT 59620-3201

Ladies and Gentleman:

I am writing to demonstrate my strong support for a the proposed Materials Science Doctorate Program to be established between Montana Tech, The University of Montana – Missoula, and Montana State University – Bozeman.

Being a Montana Tech graduate, I am well aware of the value and stature that a degree earned form Montana Tech brings to a student. Tech is globally recognized as an "institution of excellence" among a small, but elite group of natural resource engineering & science based universities. Offering a Materials Science Doctorate program in the Montana University System will bring valuable opportunities to students. Additionally, the importance of researching & developing new and better materials is important to Montana's economy. The establishment of new Montana based business opportunities spawned from this program is a realistic potential byproduct of the program.

The benefits of the proposed Doctoral program to Montana are numerous. There should be no hesitation in the approval of the program. Please fee free to contact me if you have any questions regarding my support of this program.

Sincerely,

Mark D. Zora

Mark D. Zora, MBA
B.S. Geophysical Engineering