Wayne State University
Department of Physics and Astronomy’s

Blueprint for the Next Decade

The Department is committed to excellence by providing a quality education to its WSU citizenry, innovative education-research programs to its undergraduate and graduate majors, nationally competitive research programs, and a regionally beneficial outreach program that enhances the overall reputation of the Department.
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Preface
Although it is always beneficial and worthy to strive to be comparable to the “top” physics graduate programs and try to emulate these departments, there is the need to understand the marketplace in which one’s own department exists and to develop its own niche and identity. The most prestigious Ivy-League and West Coast schools have strong programs in most branches of physics owing to the size of their faculty (2-to-3 times that of Wayne’s), the availability of resources, and a longstanding history from the earliest developments in these fields. In addition most of the top ten graduate departments in physics are at private institutions and correspondingly do not have the same economic and legislative pressures that state-supported institutions must face. Thus an approach to apply a scaled-down “Ivy-League” model for departmental planning neither takes advantage of the uniqueness of Wayne State’s midwestern urban setting nor considers the type of graduate students we attract. Instead, departments like ours must make judicious choices and focus on a few areas of excellence if we are to have a sufficient (critical) mass of research active faculty to compete nationally for recognition and funding dollars in these disciplines. In fact, physics departments of comparable faculty size to ours have a sizeable number of faculty typically in just three areas - condensed matter physics and two of the following: astrophysics, nuclear, or particle physics. Furthermore the only comparable size department in the top 10 of the most recent National Research Council ranking, University of California at Santa Barbara, has 95% of its faculty concentrated in only three areas. This indicates that building upon existing expertise and strengths can achieve national recognition and stature without having to have the breadth or diversity of programs that exists at much larger departments. Likewise, these areas of faculty concentration must respond to graduate student interests in order to have a significant positive impact on graduate student recruitment, retention, and ultimately graduate rates if we are to maintain viable undergraduate and graduate programs. It is much easier to convince the university administration to support new initiatives as well as our existing research programs when they (i) involve broad participation with other WSU departments and the private sector, (ii) result in increasing graduate student admissions and graduation rates, and (iii) produce the anticipated increase in funding and national visibility. The level of university support for these programs will be evaluated on these three criteria and new initiatives will no longer merit high priority if they are primarily based on item (iii). Thus the same criteria should be used in own determination of our future research directions and priorities to implement them.

1 See Figure 1and Table 1 in the appendix.
2 See Table 2 and Figures 8 & 9 in the appendix.
Objectives
The goal of this *Blueprint for the Next Decade* is to enhance the overall reputation and stature of the physics department within the College, the University, our local and state constituencies, and the national and international physics communities. By considering both internal and external factors, the department will pursue an approach that focuses on research and educational initiatives that achieve the following objectives:

- increase the size of the graduate and undergraduate physics student population,
- improve the quality of the graduate programs,
- sustain the funding growth of the past decade, and
- ensure that other aspects of our education and research missions are adequately addressed to enhance the overall reputation of the Department.

Factors
During the past year, the Department has had to prioritize issues and factors that permit achievement of the preceding objectives, especially in light of the 2% reduction in the permanent budget mandated by the University. In reviewing departmental statistical data and trends, it quickly became apparent that reversing the declining enrollment trends of undergraduate and graduate physics students has to be one of the top, if not the top issue in developing factors if the Department is to maintain highly viable undergraduate and graduate programs without any further loss of faculty lines and research capacity. After gathering input from the Executive Committee and listening to many other faculty members, the following factors have emerged as being most important in guiding the future growth and development of the Department and correspondingly in formulating new initiatives and hiring new faculty:

- enhance existing strengths in the Department
- recognize graduate student interest, both locally and nationally
- promote areas of strong post-education employment opportunities
- promote multidisciplinary research and teaching
- create partnerships with local industry and government (urban mission)
- diversify and broaden funding sources
- increase funding level, especially with respect to graduate student support and research stimulation moneys (IDC)
- ensure flexibility for future research opportunities

With the present availability of five tenure-track positions and possibly one or two more vacancies owing to pending retirements in the next two years, it is imperative that the Department carefully considers these factors in order to determine the best approach towards achieving our long-term objectives while taking advantage of this opportunity to initiate new research thrust(s) with a sufficient core of faculty that can make an immediate and significant impact on our future.

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3 A more complete presentation and discussion of the factors and statistical data used in this analysis and requested by the Dean’s budget reduction committee last year, which ultimately resulted in the loss of a faculty position, can be found in the appendix.
Proposal

After reviewing the preceding factors and assessing the needs of the department to sustain both intellectual and research growth as well as from discussions at the Dean and Vice-President for Research levels to gauge their support for various programs and initiatives, there are three areas that we should target for development over the next decade: nanosciences, biosciences, and theoretical physics. The thrust into nanosciences represents a major effort to strengthen our programs in condensed matter/material/applied physics and to ensure a strong research presence in the area that is rapidly emerging as the science leading to most of the technological advances to be achieved over the next two decades. Based on faculty distributions at the top-ranked departments of comparable size, national student interest, and more importantly, the type of graduate students we attract and that complete graduate degrees, a vigorous condensed matter/material/applied physics program must be maintained in order to sustain a viable graduate research program. With nearly a 50% reduction in the number of experimental condensed matter physics faculty owing to attrition and retirement since 1992, a natural decline in productivity due to advancing age of these faculty (average age is 56 with an average time since awarding of Ph.D. degree of 27 years) and no hires in the past 11 years, a revitalization of this area should be the top priority of any major faculty hiring thrust during the next decade. Biosciences thrust represents a new, but small venture into a non-traditional area of physics that plays on the interdisciplinary interactions between the life and physical sciences. With strong interest at both the state- and university-levels in supporting biomedical sciences, it is important that the Department seizes this opportunity and establishes a connection to this area. Hires in theoretical physics represent replacements of faculty in this area and complement existing experimental programs. Faculty hires in all three areas will be prioritized in an integrative fashion with the final implementation being dependent upon future retirements, any attrition of existing faculties, and adequate budgetary and personnel resources being available. Furthermore some flexibility in hiring will be preserved in order not to miss other opportunities when they exist. For example, in the mid-1990’s with the restructuring of several research laboratories, most notably AT&T Bell and IBM, many universities and physics departments used this opportunity to successfully recruit some of the best physicists from these labs to booster their ranks. Likewise there may be a need to move quickly into other or new non-traditional physics areas because of breakthrough discoveries.

Nanosciences

One of the most important new frontiers in science is in the area of nanosciences. Nanotechnology, designer materials, and tailor-made materials are becoming more and more frequently found in the print media that the general public read. The technological potential is limitless. Federal funding agencies see nanotechnology as a growth area and are making sizeable investments into this area. For example, President Clinton proposed major increases in federal spending on research on information technology, biomedical science, and nanotechnology in the FY 2001 budget with NSF receiving a 17% increase in its budget. As shown in the accompanying document in the appendix the National Nanotechnology Initiative (NNI) is proposing an 83% ($225-M) increase in funding in this area alone for FY 2001. Besides the funding and technological potential, studies of mesoscopic physics and nano-structure materials posed many problems that physicists can solve - from
understanding the fundamental physics and the material issues in these nanoscale structures to developing innovation material processes at the molecular and nanometer level, and even to applying this knowledge and expertise to developing new types of devices. Clearly physicists trained in condensed matter, material, applied, and device physics will make a sizeable impact in this area and the Department will need to have a major presence in this area if we want to have a nationally competitive program in condensed matter/material/device physics in the future. By developing a strong research program in nanosciences that spans basic to applied physics and that incorporates a mixture of both technical and scientific expertise with the appropriate research support personnel and laboratory infrastructure, the Department can present a concerted effort with increased funding opportunities from NSF, DoD, DoE, DARPA, and even NASA. Few other programs can seek moneys from such a diversity of funding agencies. Thirdly, students will be attracted to such programs because of the nature of the research as well as the post-graduate employment opportunities in these fields since over 50% of all practicing physicists are employed in the private sector. Already research laboratories at Seagate, 3M, Intel, and other companies are seeking qualified researchers in the field of nanosciences and nanoscale materials, and the trend will continue well into the next several decades.

The proposed initiative in nanosciences would focus on nanostructured materials and mesoscopic physics, which encompasses a rather broad list of possibilities as exemplified by the faculty candidates being interviewed this year. For example, quantum heterostructures of GaAs and GaN exhibit unusual physical properties such as the quantum Hall effect while others have been developed as nanolasers owing to a better understanding of their optical properties. Below are listed several sub-branches that will create a research niche yet complement existing interests/strengths in the Department as well as significantly increase the department's extramural funding and capabilities:

- mesoscopic physics and phenomena of nanowires
- magnetic studies of nano-particles and structures
- studies of semiconducting heterostructures, e.g., quantum wells
- optical studies of nanoscale structures and materials
- investigations of photonic materials
- studies of single molecule electronics, e.g., quantum cellular automata
- fabrication and synthesis of nanoscale structures and materials
- development of device physics

Although each of these sub-areas can be considered its own research enterprise, there are elements of overlap in terms of the laboratory apparatus for fabrication and structural characterization of these nanoscale materials. It is clear that the most successful programs in condensed matter physics have a core of 4-to-6 faculty members in an area, such as, superconductivity. Thus the best approach will be to hire at least 4 faculty initially with each hire having expertise in a different sub-area of nanosciences in order to cover as many sub-areas as possible to ensure a multifaceted capability in this condensed matter, material, applied, and device physics initiative. Furthermore, this initiative would be a strong complement to the Smart Sensor and Integrated Device (SSID) program and is critical if the
Department is to be a major player in the development of programs associated with the proposed university technology park. This research area would also permit additional funding opportunities with the private and industrial sectors and enhance the probability of the University attracting multi-million dollar Center-based (e.g., STC or MSERC) grants in nanotechnology. In addition, the funding associated with these individual investigator programs typically support several graduate students per faculty member as well as postdocs and generate full indirect costs that can further stimulate additional research activities in the Department. Thus the hiring of four faculty in this area should have the top priority and can be accommodated within the present number of vacancies and planned retirements. The ongoing search in condensed matter physics would be the first appointments in this area.

This new initiative into nanosciences (nanostructured materials and mesoscopic physics) will also play a pivotal role in attracting students to the Department and increasing the number of undergraduate and graduate majors. Nationally, the areas of condensed matter physics, material physics, optics, and applied physics account for well over 50% of all physics graduate students and this is also true at Wayne State as well. With increasing competition for American graduate students, the Department must develop a stronger program in this area if it is to sustain a viable graduate program.

**Biosciences/Biological Physics**

A second area that is ripe for a strong programmatic push is in biosciences/biological physics. Presently the State of Michigan in collaboration with WSU, U of M, and MSU is proposing a “Life Science Corridor” similar to Silicon Valley to stimulate research and technology in the biosciences and biomedical sciences. The proposal is that the State earmarks its tobacco settlement moneys to support the infrastructure and collaborative research programs in biosciences at the tune of $50-M per year for 20 years. Notwithstanding the attractiveness of the funding potential from this source and the fact that our larger sister physics departments are also infatuated with garnering a share of these moneys (note MSU physics department will be moving into a new biomedical and physical science building by 2001 and U of M currently has a faculty search in biophysics), there are several other factors to consider. The limelight that physicists enjoyed during the 20th century is slowly being lost to new areas such as biology and the medical sciences. Not only is this being manifested by a 27% decrease in the number of physics graduate students from 1992 to 1997, but it is also being felt in the fraction of federal science dollars being spent on the physical sciences and engineering (PS&E) research. In 1997 PS&E research received less than one-third of all federal science dollars as compared to one-half in 1970. By contrast, general funding for the biosciences and medical sciences has grown from less than 30% to 43% in the same time frame. Moreover biosciences is gradually transforming from a qualitative science to being more quantitative and utilizing fundamental physical laws to understand complex behavior at the molecular level. As physicists begin to study physical properties of matter on nanometer-size structures, they are approaching the length scale of molecular biological systems and thus can make valuable insights and contributions in this

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4 Faculty distribution based solely on graduate student sub-fields nationally would result in 50% more faculty in condensed matter physics than the combined number in particle and nuclear physics. See AIP Graduate Student Reports for 1996 and 1997 in appendix.
area. Getting into the biological physics area at the infancy or even adolescent stage can be done at a more modest level than attempting to play catch up later on. The program would consist of two-to-three faculty initially and perhaps having joint appointments with biology. The preference will be to have the initial hire at a more senior level since we have no prior experience/expertise in this field in our department. One plausible scenario is that this program takes advantage of the nanoscience initiative and piggybacks off of the materials processing and technology capabilities and expertise of this initiative in studies and development of biomagnetic markers, diagnostic sensors, drug encapsulation and delivery, etc. Faculty hiring in this area would commence as faculty positions became available either through vacancies created by faculty leaving the department or retirements beyond those presently planned.

As with any initiative into a new field of physics that does not have a longstanding history nationally, it is difficult to gauge student interest. According to the AIP 1997 Graduate Student Report, 3% of graduate doctoral students with 3+ years of study are in biophysics. Although this appears to be a small percentage, it is growing and more impressive if normalized to the number of faculty in this area. With the formation of collaborative research ventures such as with our nanoscience initiative and the Karmanos Cancer Institute, the biological physics area should attract similar numbers of students per faculty member as the nanoscience initiative. Furthermore, this opens the possibility for undergraduate biology and pre-med majors to explore an alternative post-baccalaureate program intermixing the life sciences with a hard physical science. The funding in this area will obviously benefit from the long-term “Life Science Corridor” state-funding initiative (duration of 20 years) and would primarily be supported at the federal level by NIH which has continually achieved the largest annual percent increases of any of the funding agencies during the past decade as well as NSF.

**Theoretical Physics**

Nationally, the best physics departments maintain strong theoretical programs to complement experimental programs as well as to generate and address their own set of fundamental physics questions. Although most top departments have a sizeable fraction of their departments involved in theoretical physics, smaller departments must conscientiously decide how large their “market” (students, funding, and sustainable scholarly activity) is. This determination is somewhat subjective and the size may be dependent upon how one presently views the present theoretical effort in the department. Suffice it to say that four additional faculty hires in theoretical physics would represent a sizeable increase. The area that needs immediate attention is the hiring of a core group to enhance/complement existing experimental programs. The first hire will be the result of the current search in the high-energy nuclear (RHIC) physics theory area this year. The Department of Energy has supported our previous tenure-track faculty member (Welke) and there is interest in continuing support for this area in the future. Also a couple of our graduate students have expressed interest in this research area. A subsequent hire would be in high-energy particle theory mainly to complement the experimental efforts in this area, perhaps as early as next year. The area(s) of the other two hires would be dictated by several factors including student interest, funding potential, and compatibility with and/or need to support an
experimental research effort. Perhaps an additional hire in the high-energy physics arena or a theorist with an interest of mesoscopic physics and phenomena to complement the nanoscience initiative would be the next priority. Based on the present needs and factors described above, these latter two hires would probably not occur during the next five years and not until the nanosciences and biological physics initiatives had been fully implemented.

**Other Possible Program Initiatives:**

**Astrophysics**

The 1996 Program Review suggested an expansion into another high-energy physics area, high-energy astrophysics. Clearly, a strong synergy between our existing high-energy nuclear and particle physics groups and astrophysics could exist with the appropriate faculty hires in high-energy astrophysics. However, it should be noted that this synergy as well as the potential for comparable funding to the nuclear accelerator/detector construction projects were previously explored during the time that the most recent high-energy physics initiative was formulated in 1995. The end result was that high-energy particle physics rather than high-energy astrophysics was deemed more desirable primarily because of funding possibilities, and then subsequently an expansion in the faculty size beyond the original proposal was made to accommodate involvement in both the CLEO and DESY research projects. It is reasonable at this time to let this particle physics initiative more fully develop and mature before deciding whether another new initiative (or an expansion) into a high-energy astrophysics of comparable faculty size (3-to-5) is prudent. In addition, the existing accelerator-detector construction projects and our potential to become involved in future projects could be severely handicapped if similar levels of long-term investment in research support personnel and moneys are required to develop another high-energy physics initiative/program in the department, especially for garnering large-scale cosmic- and x-ray detector project funding. Consequently an initiative or even a smaller scale expansion into high-energy astrophysics should only be considered if sufficient number of vacancies within the existing faculty positions in the high-energy nuclear and particle physics areas become available and if stronger rationale is forthcoming that addresses the factors described on p.3, especially those dealing with graduate student factors such as recruitment and post-graduate employment opportunities.

**Astronomy**

Likewise, astronomy has been suggested on numerous occasions as another possibility for a research initiative with a core of new faculty hires. Arguments range from the undeniable student interest based on our introductory-level astronomy courses to the departmental name is Physics and Astronomy. Although some astronomy research no longer requires extended periods at national or international observatories and away from their normal teaching duties, there are several other factors to consider that make this less attractive at the present time. Most of the top astronomy faculty and research reside in separate astronomy departments, or at least within large astronomy programs with some self-autonomy from the physics departments. The smallest critical mass would be three faculty members to attain any national visibility, but five would be more realistic based on the astronomy/astrophysics
faculty size at comparable size departments. Secondly, graduate astronomy (and even astrophysics) programs require essentially a separate curriculum, or at least the introduction of a half-dozen new graduate-level courses in astronomy/astrophysics. Our department already suffers from not being able to offer specialized graduate courses on a regular basis as part of our normal teaching/lecture assignments due to the faculty size in comparison to the undergraduate and graduate course offerings required just to maintain our present physics programs. Likewise because of a different curriculum for undergraduate astronomy majors, different standards for graduate admissions and qualifying exams can be anticipated. Also it should be noted that students taking our introductory-level descriptive astronomy course rarely have the mathematical sophistication necessary even to take AST 5010, an intermediate level course. Thus it is doubtful that the student interest generated internally would translate into undergraduates matriculating into astronomy graduate programs at any higher frequency than that for any other existing research program in our department. The recruitment of astronomy and astrophysics graduate students is an especially serious concern since astronomy graduate programs attract fewer foreign students. With 27% of the astronomy doctorates awarded in 1997 being to foreign students as compared to nearly 50% in physics, there would be stiff competition with the large well-established astronomy programs at U of M and MSU for the few American students that we seem to be able to attract presently. It is highly doubtful that an initiative into astronomy (and/or astrophysics) will significantly enhance our graduate student population, and thus cannot be considered a high priority at this time.

Space Sciences
Most recently, space sciences involving terrestrial and planetary science research typically not associated with astrophysics and astronomy programs has been suggested as another alternative for a new program thrust. These research projects can range from the development and construction of space satellite components to studies of atmospheric and geological conditions of our own Earth system. With the large public interest presently being shown in space, this area could appeal to student interest as well as attract funding from NASA. However, this area has only minimal overlap with existing research areas in the department, minimal interdisciplinary involvement with other university faculty, and less impact on the local/state economy than the other research initiatives being presented. This means that the required critical mass of 3-to-5 faculty members to gain significant national recognition and funding would have to come solely from physics faculty positions. In addition, several support engineers and technicians are required if the group is to become involved in construction and development projects with the largest funding potential. A smaller effort of 2-or-3 faculty hires would require a collaborative effort with another university, since Wayne State is neither located near an industrial aerospace company nor a NASA space center/research lab. The University of Michigan with its Department of Atmospheric, Oceanic, and Space Sciences is the closest university with an emphasis in this area, although it should be noted that this department is actually in the College of Engineering at U of M and consists of over thirty professorial and research faculty members in just the space sciences. In addition, U of M has a separate Department of Aerospace

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Engineering that provides additional synergy to this program. Thus the extent in which Wayne State could undertake a leadership role in such collaborative projects would be subject to question. In fact, the (University of) Michigan Space Grant Consortium which provides small seed grants is led by University of Michigan with Wayne State and eight other colleges considered as affiliate universities. Furthermore, a space science curriculum would require many new courses and different admission standards in order to be competitive with U of M’s program in the recruitment of students as well as faculty. Thus for these and many of the same reasons as previously outlined for the astrophysics and astronomy initiatives, a space sciences initiative should not be considered a high priority for faculty hires until the nanosciences and biosciences initiatives are more firmly established. Perhaps after hiring a strong core of faculty researchers and developing the facility capabilities in nanosciences, an expansion of the nanosciences initiative with 1-or-2 additional faculty hires that have an interest and expertise in space sciences is a more reasonable approach into this research area. In fact, NASA has a strong interest in developing nano-and micro-systems and technologies for their manned space programs as well as the largest percent increase in funding for nanotechnology for FY 2001 from the National Nanotechnology Initiative.
The table below displays comparisons of the extent that a new high-energy astrophysics/astronomy initiative and the proposed expansions into nanosciences, biosciences, and theoretical physics address the factors described previously on p.3.

**Comparisons of Program Initiatives with respect to various factors.**

<table>
<thead>
<tr>
<th></th>
<th>Astrophysics/ Astronomy</th>
<th>Space Sciences</th>
<th>Nanosciences</th>
<th>Biosciences</th>
<th>Theoretical</th>
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<td><strong>Synergy w/ existing programs</strong></td>
<td>HEP</td>
<td>RHIC</td>
<td>Condensed matter</td>
<td>Condensed matter</td>
<td>RHIC</td>
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<tr>
<td></td>
<td>Material physics</td>
<td>Nanosciences</td>
<td>HEP</td>
<td>HEP</td>
<td>(Cond. Matter)</td>
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<td></td>
<td>Applied physics</td>
<td>Smart sensors</td>
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<td><strong>Grad Student interest</strong></td>
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<td>very good</td>
<td>good</td>
<td>fair</td>
</tr>
<tr>
<td><strong>Grad student recruitment</strong></td>
<td>?</td>
<td>?</td>
<td>strong</td>
<td>good</td>
<td>fair</td>
</tr>
<tr>
<td><strong>Post-graduate opportunities</strong></td>
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<td>good</td>
<td>very good</td>
<td>good</td>
<td>good</td>
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<td></td>
<td>(if in computation)</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td><strong>Interdisciplinary nature</strong></td>
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<td>engineering chemistry</td>
<td>bioengineering</td>
<td>not typical</td>
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<td>biology</td>
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<td>?</td>
<td>strong</td>
<td>good</td>
<td>?</td>
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<td></td>
<td></td>
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<td>NSF</td>
<td>NIH</td>
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<td>NASA</td>
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<tr>
<td></td>
<td>Private sector</td>
<td></td>
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<tr>
<td><strong>Fundability</strong></td>
<td>good</td>
<td>fair</td>
<td>excellent w/ Nat’l Nanotechnology Initiative</td>
<td>very good w/ “Life Science Corridor” Initiative</td>
<td>good</td>
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<td>additional graduate courses</td>
<td>additional graduate courses</td>
<td>federal growth area fills loss of condensed matter faculty</td>
<td>future growth area state interest</td>
<td>complements existing programs</td>
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<td>off-campus research req’d</td>
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<tr>
<td><strong>Faculty required</strong></td>
<td>3 – 5</td>
<td>3 – 5</td>
<td>4 +</td>
<td>2 – 3</td>
<td>2 +</td>
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</table>
**Education**

Rethinking (thinking out of the box) and restructuring of our graduate and undergraduate programs/curricula must be undertaken in order to increase the number of majors in physics. Number of required courses, time to degree, utility of courses, and degree marketability are negative factors (perhaps misperceptions) that adversely affect our ability to attract students to our programs and then to retain them, especially at the graduate level. The discussion during the past year primarily focused on modifying our program requirements to permit greater flexibility in the selection of courses. For example, changes in our undergraduate applied physics degree requirements in Fall 1998 have been approved so that programs in material physics, electrical engineering/electronics, computational physics, and biophysics are now available. This is a first step as the awarding of degree certificates indicating the specialization is still needed and it would be extremely beneficial to develop a formal training internship program with industrial/corporate sponsors for these students during the next year. Co-op programs have been highly successful in engineering schools as both students and corporate employers recognize the advantages of such programs. At the doctoral level, the minimum number of core courses required for the Ph.D. was reduced to six (PHY 7110, 7200, 7400, 7410, 7500, and 7600) as of Spring 1999. This reduction will permit thesis advisors to tailor their student's plan of work to the research needs of that physics sub-discipline and permit the registering of courses outside of physics as part of their program. (Note that registration of courses outside physics require departmental graduate officer approval unless already part of an approved plan of work for the student.) This reduction was critical if physics majors were going to participate in interdisciplinary initiatives such as the NSF-IGERT funded SSID program or the Scientific Computing initiative. Likewise having the flexibility in graduate course selection will make our students more marketable in other more traditional physics fields as well. Lastly, the formation of new niche-based masters degree programs need to be developed to boost our graduate program enrollments in light of federal, state, and university recommendations. The addition of faculty in the nanosciences/condensed matter physics area will allow us to develop a strong and highly visible interdisciplinary masters degree program in applied physics. As presently envisioned, masters-degree students would have the opportunity to take a set of interdisciplinary courses that include laboratory-based training courses modeled after the SSID curriculum. These students would even have the possibility of working with industrial researchers at Ford or Delphi as part of this thesis research, or possibly in the technology park once it is established. Without additional faculty in this area, our masters-level enrollment will not increase and a critical labor need in the industrial/corporate market will not be filled by Wayne State graduates. Similarly, one could envision a masters degree program based on the biosciences initiative attracting students and provide them with the training for ample employment opportunities.

Another set of programs of highly successful programs geared to promote and attract physics majors is the NSF-funded Research Experiences for Undergraduate (REU) programs in smart sensors and high-energy particle (CLEO) physics areas. There should be a strong impetus to expand upon these REU programs, and in fact, the CLEO REU program has been expanded to include the nuclear RHIC group's involvement. In addition, a physicist from AT&T Bell Labs

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6 Addresses specific recommendations from the 1998 Congressional Report chaired by MI Congressman V. Ehlers entitled “Unlocking Our Future Report Toward a New National Science Policy” and from the goals set forth in WSU President I. Reid’s 1998 inauguration address.
has approached us to expand our REU program to send students to their labs in the summer. Obviously, the nanoscience initiative would be a natural for the development of a WSU - AT&T Bell Lab REU collaboration.

At the introductory physics level, discussions at the committee level are being arranged to determine whether a new departmental-wide approach to teaching at this level is needed and what, if any, approach that should be followed. Apparently there is a wider range of opinions and sentiments on this topic than any other issue in the department. The objectives for this initiative have been requested and the thought is that any change in the course and/or lecture format should enhance the learning effectiveness of the students through improved problem solving skills and conceptual understanding, create a more conducive environment to learn physics by inquiry, generate enthusiasm and interest in physics and science in general, and thus make these courses more enjoyable and professionally stimulating to the faculty teaching these courses. Measures of success would be assessed by better student performance on exams, an increase in the number of students taking PHY 3300 and becoming physics majors, better-prepared majors for our intermediate-level courses, and an improved sense of satisfaction by the faculty. The Department is committed to improving in this area and will find innovative solutions to overcome scheduling and manpower problems if required. A truly integrated approach between the lecture and quiz section, and even with the laboratory sections seems quite attractive after listening to Ken Heller describing the program at University of Minnesota; however, this structure would be a “radical” departure from our present one and would create an administrative nightmare initially for scheduling classes and labs. Furthermore, this approach would require a more unified approach to teaching with less independence for a faculty member teaching the courses and clearly more work. Another related issue is that we are seriously considering a “help room” on the first floor that PHY 2130 – 2185 students could get assistance at any time during the day. This room would be manned by GTAs as part of their TA responsibilities (and perhaps faculty in lieu of office hours) to field questions, help with homework, etc.

Likewise many faculty have initiated their own version of Web-based instruction, from just posting syllabi to displaying lecture notes and problem solutions on their own web pages and sites. A more interactive approach with homework assignments being handled and graded on the Web is found at many universities. Obviously there is a sizeable time investment if each faculty member develops his or her own program. Again a unified approach towards teaching at introductory level benefits Web-based instruction in terms of time, instructional capabilities, and the ability to utilize fully developed Web-based programs from MSU, Illinois, and Texas to name a few.
**Outreach**
Through a variety of programs, the Department has been actively involved in outreach and community service and should plan to continue and expand on many of these successful programs. These include the planetarium, which has been a focal point of the outreach for the Department and the College since its opening in 1997, and the development of weather stations and astronomy dome projects, which have active involvement of Detroit area science teachers and classrooms. Most recently, the Department has spearheaded a new graduate fellowship-training program with NSF funding for aiding K-12 science teaching in the Detroit school system. Additionally the proposed M.A. of Multidisciplinary Sciences for middle and high school teachers will provide us the opportunity to train science teachers at a more appropriate level of physics that the teachers are seeking as well as with the most recent advances in the field of physics. Other opportunities including Saturday morning science workshops and summer science camps can be developed and will be strongly encouraged.

**Summary**
There are many aspects to this departmental blueprint covering the first decade of the new millennium including new research initiatives and educational developments based primarily on the three factors shown below. Thus the present document is a work under progress and subject to review and revision. Faculty input is welcomed as there may be points that need further clarification or issues that require inclusion. Hopefully one gets a sense of the rationale and overall integration of the various initiatives being presented. Details of the actual implementation will require additional planning and serious commitment and support from the faculty since they affect everyone. In the long run, this blueprint should benefit all faculty in improving the reputation and stature of the department within the College, the University, our local and state constituencies, and the national and international physics communities. With broad-based faculty support in fine-tuning this blueprint and its implementation, we will succeed.
APPENDICES

National Nanotechnology Initiative Report

Faculty Distribution at Comparable Size Departments

AIP Graduate Student Report Table, 1996 & 1997

WSU Physics Enrollment, Graduate Student, & Funding Trends
“My budget supports a major new National Nanotechnology Initiative, worth $500 million. 
... the ability to manipulate matter at the atomic and molecular level. Imagine the possibilities: materials with 
ten times the strength of steel and only a small fraction of the weight -- shrinking all the information housed at 
the Library of Congress into a device the size of a sugar cube -- detecting cancerous tumors when they are only 
a few cells in size. Some of our research goals may take 20 or more years to achieve, but that is precisely why 
there is an important role for the federal government.”

--President William J. Clinton

January 21, 2000

California Institute Of Technology

President Clinton’s FY 2001 budget request includes a $225 million (83%) increase in the 
federal government’s investment in nanotechnology research and development. The 
Administration is making this major new initiative, called the National Nanotechnology 
Initiative (NNI), a top science and technology priority. The emerging fields of nanoscience 
and nanoengineering – the ability to precisely move matter - are leading to unprecedented 
understanding and control over the fundamental building blocks of all physical things. These 
developments are likely to change the way almost everything – from vaccines to computers to 
avtomobile tires to objects not yet imagined – is designed and made.

The initiative, which nearly doubles the investment over FY 2000, strengthens scientific 
disciplines and creates critical interdisciplinary opportunities. Agencies participating in NNI 
include the National Science Foundation (NSF), the Department of Defense (DOD), the 
Department of Energy (DOE), National Institutes of Health (NIH), National Aeronautics and 
Space Administration (NASA), and Department of Commerce’s National Institute of 
Standards and Technology (NIST). Roughly 70% of the new funding proposed under the NNI 
will go to university-based research, which will help meet the growing demand for workers 
with nanoscale science and engineering skills. Many of these research goals may take 20 or 
more years to achieve, but that is precisely why there is an important role for the Federal 
government.

<table>
<thead>
<tr>
<th>Nanotechnology Research and Development Funding by Agency:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Agency</strong></td>
</tr>
<tr>
<td>National Science Foundation</td>
</tr>
<tr>
<td>Department of Defense</td>
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<tr>
<td>Department of Energy</td>
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<tr>
<td>NASA</td>
</tr>
<tr>
<td>Department of Commerce</td>
</tr>
<tr>
<td>National Institutes of Health</td>
</tr>
<tr>
<td>TOTAL</td>
</tr>
</tbody>
</table>
Nanotechnology is the builder’s new frontier and its potential impact is compelling: In April 1998, Dr. Neal Lane, the Assistant to the President for Science and Technology remarked, “If I were asked for an area of science and engineering that will most likely produce the breakthroughs of tomorrow, I would point to nanoscale science and engineering.”

This initiative establishes Grand Challenges to fund interdisciplinary research and education teams, including centers and networks, that work for major, long-term objectives. Some of the potential breakthroughs that may be possible include:

- Shrinking the entire contents of the Library of Congress in a device the size of a sugar cube through the expansion of mass storage electronics to multi-terabit memory capacity that will increase the memory storage per unit surface a thousand fold;
- Making materials and products from the bottom-up, that is, by building them up from atoms and molecules. Bottom-up manufacturing should require less material and pollute less;
- Developing materials that are 10 times stronger than steel, but a fraction of the weight for making all kinds of land, sea, air and space vehicles lighter and more fuel efficient;
- Improving the computer speed and efficiency of minuscule transistors and memory chips by factors of millions making today’s Pentium IIIs seem slow;
- Using gene and drug delivery to detect cancerous cells by nanoengineered MRI contrast agents or target organs in the human body;
- Removing the finest contaminants from water and air and to promote a cleaner environment and potable water;
- Doubling the energy efficiency of solar cells.

The NNI Investment Strategy:

The President’s Committee of Adviser’s on Science and Technology (PCAST) established a PCAST Nanotechnology Panel comprised of leading experts from academia and industry to provide a technical and budgetary review of the NNI which is detailed in the National Nanotechnology Initiative – Leading to the Next Industrial Revolution report released today. Upon review of this initiative, PCAST strongly endorsed the establishment of the NNI, beginning in Fiscal Year 2001, saying that ‘now is the time to act.’ In PCAST’s December 14, 1999 letter to President Clinton, PCAST described the NNI as a top Administration priority and an excellent multi-agency framework to ensure U.S. leadership in this emerging field that will be essential for economic and national security leadership in the first half of the next century.

This initiative builds upon previous and current nanotechnology programs, including some early investment from some of the participating agencies. The research strategy listed below is balanced across the following funding mechanisms: fundamental research, Grand Challenges, centers and networks of excellence, research infrastructure, as well as ethical, legal and social implications and workforce programs. This strategy has been endorsed by PCAST. This initiative initially supports five kinds of activities:
Long-term fundamental nanoscience and engineering research that will build upon a fundamental understanding and synthesis of nanometer-size building blocks with potential breakthroughs in areas such as materials and manufacturing, nanoelectronics, medicine and healthcare, environment and energy, chemical and pharmaceutical industries, biotechnology and agriculture, computation and information technology, and national security. This investment will provide sustained support to individual investigators and small groups doing fundamental, innovative research and will promote university-industry-federal laboratory and interagency partnerships.

Grand Challenges that are listed above.

Centers and Networks of Excellence that will encourage research networking and shared academic users’ facilities. These nanotechnology research centers will play an important role in development and utilization of specific tools and in promoting partnerships in the coming years.

Research Infrastructures will be funded for metrology, instrumentation, modeling and simulation, and user facilities. The goal is to develop a flexible enabling infrastructure so that new discoveries and innovations can be rapidly commercialized by the U.S. industry.

Ethical, Legal, Societal Implications and Workforce Education and Training efforts will be undertaken to promote a new generation of skilled workers in the multidisciplinary perspectives necessary for rapid progress in nanotechnology. The impact nanotechnology has on society from legal, ethical, social, economic, and workforce preparation perspectives will be studied. The research will help us identify potential problems and teach us how to intervene efficiently in the future on measures that may need to be taken.

**Funding by NNI Research Portfolio:**

<table>
<thead>
<tr>
<th></th>
<th>Fundamental Research</th>
<th>Grand Challenges</th>
<th>Centers and Networks of Excellence</th>
<th>Research Infrastructure</th>
<th>Ethical, Legal, and Social Implications and Workforce</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>FY 2000</td>
<td>$87M</td>
<td>$71M</td>
<td>$47M</td>
<td>$50M</td>
<td>$15M</td>
<td>$270M</td>
</tr>
<tr>
<td>FY 2001</td>
<td>$170M</td>
<td>$140M</td>
<td>$77M</td>
<td>$80M</td>
<td>$28M</td>
<td>$495M</td>
</tr>
</tbody>
</table>

Next Steps:
The Administration is currently evaluating the mechanisms to establish a coordination office that would support the NNI and an external review board of experts that would annually monitor the NNI goals. These issues will be detailed in an implementation plan to be published latter this Spring.

Detailed background and information on the NNI is located on the [www.nano.gov](http://www.nano.gov) website.
This histogram (Fig. 1) shows the relative distribution of faculty in various sub-fields of physics from comparable size physics departments (faculty size of 32 ± 5) according to Table 1 as well as that of the Wayne State physics department. This clearly indicates an under-representation of 3-to-4 faculty in condensed matter physics at WSU when compared to similar size departments. In fact, WSU has the smallest number of condensed matter physics faculty of any of these departments except for University of Iowa, which has had a long history in space sciences starting with Professor van Allen in the early 1950’s. Furthermore the spreadsheet on the next page indicates that these departments of comparable faculty size tend to focus on three areas of research - condensed matter physics and typically two of the following three areas: astrophysics, nuclear, or particle physics.

**Figure 1.**

Source: 1998 AIP Graduate Programs in Physics & Astronomy
### Table 1.

**Distribution of Physics Faculty by Sub-field**

At Comparable Sized Departments

<table>
<thead>
<tr>
<th>NRC Ranking</th>
<th>Institution</th>
<th>Type</th>
<th>Setting</th>
<th>Faculty Size</th>
<th>Astronomy/ Astrophysics</th>
<th>Atomic</th>
<th>Biophysics</th>
<th>Condensed Matter</th>
<th>Nuclear</th>
<th>Particle</th>
<th>Other</th>
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<td>4</td>
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<td>1</td>
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<td>1</td>
<td>14</td>
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<td>2</td>
<td>8</td>
<td>3</td>
<td>11</td>
<td>2</td>
<td></td>
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<td>2</td>
<td>2</td>
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<td>10</td>
<td>6</td>
<td>7</td>
<td>5</td>
<td>4</td>
</tr>
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<td>3</td>
<td>3</td>
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<td>1</td>
<td>2</td>
<td></td>
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<td>7</td>
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<td>8</td>
<td>7</td>
<td>6</td>
<td></td>
</tr>
</tbody>
</table>

**Totals:**

- 91
- 28
- 13
- 229
- 84
- 126
- 59

**Distribution Percentage:**

- 14%
- 4%
- 2%
- 36%
- 13%
- 20%
- 9%

**WSU Percentage:**

- 0%
- 9%
- 0%
- 25%
- 25%
- 22%
- 19%

Source: 1998 AIP Graduate Programs in Physics & Astronomy

Number of faculty in sub-field: 

- 10 + faculty
- 8 - 9 faculty
- 6 - 7 faculty
### Table 2. Sub-field for graduate students with 3+ years of study at physics PhD-granting departments, 1995-97

<table>
<thead>
<tr>
<th>Field</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condensed matter/materials/optics (inc. surface physics)</td>
<td>33</td>
</tr>
<tr>
<td>Particles and Fields</td>
<td>15</td>
</tr>
<tr>
<td>Astronomy &amp; Astrophysics</td>
<td>11</td>
</tr>
<tr>
<td>Nuclear Physics</td>
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</tr>
<tr>
<td>Atomic &amp; Molecular</td>
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</tr>
<tr>
<td>Biophysics</td>
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</tr>
<tr>
<td>Applied Physics</td>
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</table>

Source: AIP 1996 and 1997 Graduate Student Reports
This past spring, the Dean requested input from each department as to the factors and issues they considered important to their growth in light of the 2% reduction in the College of Science budget mandated by the University. In addition, statistical information and data about class enrollments, number of undergraduates and graduate majors, graduation rates, teaching loads of TAs and faculty, funding levels, etc., were requested before deliberations were undertaken by the Dean and his budget reduction committee on how to implement a 2% reduction in essentially personnel costs. After reviewing the data (see Figs. 2 -11), the Executive Committee came to a consensus that reversing the declining enrollment trends in undergraduate and graduate physics majors was a top priority. Any curricular changes and research initiatives have to address this issue; otherwise the Department could anticipate further reductions in its faculty ranks during the next decade.

Based on the trends exhibited in these figures, it was not surprising that the final recommendation for the physics department was a loss of one faculty position. The department experienced (i) a 57% decrease in undergraduate physics majors since FY 1993, which is well above the national average for PhD-granting institutions (ii) a 23% decline in the number of graduate students during the same period, which is about the same as the national rate, and (iii) no increase in extramurally supported GRAs from FY 1990 through FY 1999 although the grant/contract funding increased by a factor of 3.5 during this time. Likewise the doctoral and masters’ degree graduation numbers have had a general decline over the past decade. This decline has been primarily a result of fewer degrees in condensed matter physics (due to fewer research active faculty and no new hires in the past 11 years in this area) not being offset by degrees from graduate students involved in the two most recent high-energy nuclear and particle physics initiatives. This decline in the number of doctoral degrees has further manifested itself in (i) a decrease in the number of VP-GRAs awarded to departmental faculty members and (ii) a decrease in the number of graduate recruiting fellowships over the past few years since the allocation and awarding of these are primarily based on doctoral productivity. The hope is that this trend will reverse as these high-energy physics initiatives mature and students complete their dissertation research. Nevertheless, factors such as student interest and student perception of post-graduate employment opportunities drive student recruitment and ultimately graduation rates, and as such, must be taken into account as research initiatives are formulated and existing programs are considered for additional faculty hires.
In the face of declining enrollment and stiffer competition for federal funding dollars, the Department has successfully promoted several new programs in order to enhance the funding base through competitive grants and by contracts for developing and constructing detectors for large-scale national/international research projects. The achievements of this pursuit are evidenced by the steady rise in grant support, even without considering the construction contracts, and the mercurial rise in our NSF ranking of total expenditures from 73rd in 1990 to 45th in 1999. This latter category of total expenditures includes university support such as the $1-M start-up funding for the high-energy particle physics initiative and other funding committed to developing a presence in detector-accelerator based physics projects as well as non-federal funding and support. Thus sustaining this growth in grant-based research funding over the past decade must also be a factor in the development of future research initiatives and thrusts.

Figure 2………….. Physics Grad Student Enrollment from FY 1990 to FY 1999
Figure 3………….. Undergraduate Physic Majors Enrollment from FY 1990 to FY 1999
Figure 4………….. Physics Degrees Conferred by Year from FY 1989 to FY 1999
Figure 5………….. Graduate Physics Degrees Conferred by Year from FY 1989 to FY 1999
Figure 6………….. Supported Fulltime Grad Student Enrollment from FY 1990 to FY 1999
Figure 7………….. Comparison of External Funding & Grant/Fellowship Supported GRAs from FY 1989 to FY 1999
Figure 8………….. Source of GRA Support from FY 1990 to FY 1999
Figure 9………….. Source of GRA Support by Sub-field
Figure 10………….. Graduate Degrees by Sub-field
Figure 11………….. Student Interest of WSU Applicants by Sub-field
Figure 12………….. Funding from Grants and Contracts FY 1989 through FY 1999
Figure 13………….. Research Expenditures as Reported to NSF
Figure 2. Physics Grad Student Enrollment

Figure 3. Undergraduate Physics Majors Enrollment
Figure 4.

Physics Degrees Conferred by Year

Figure 5.

Graduate Physics Degrees Conferred by Year
Figure 6. **Source of Fulltime Graduate Student Support**

![Chart showing the source of fulltime graduate student support from various categories such as Dept GTA, Dept GRA, Fellowship, VP-GRA, and Grants/Contracts over the years 90 to 99.]

Figure 7. **Comparison of External Funding and Grant/Fellowship Supported GRAs**

![Chart showing the comparison of external funding and the number of GRAs supported by grants and fellowships over the years 89 to 99. The chart includes two axes: one for funding level in $1000's with values ranging from $0 to $3,500 and another for the number of GRAs supported by grants and fellowships with values ranging from 0 to 20.]
Figure 8.

Source of GRA Support (Non-Dept Sources) by Year

Figure 9.

Source of GRA Support by Sub-field

Period: FY 91 - FY 99
Figure 10.

Graduate Degrees by Sub-field

Period: FY 89 - FY 99

Figure 11.

Student Interest by Sub-field

Percent of WSU Applications

Sub-field
Figure 12.

Grant/Contract Funding

<table>
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<th>Year</th>
<th>Funding (in $1000's)</th>
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<td>98</td>
<td>$4,000</td>
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<tr>
<td>99</td>
<td>$4,500</td>
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</tbody>
</table>

Source: NSF

Figure 13.

Total R & D Expenditures in Physics

- Federally financed
- Other sources

<table>
<thead>
<tr>
<th>Year</th>
<th>Expenditures (in $1000's)</th>
</tr>
</thead>
<tbody>
<tr>
<td>90</td>
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</tbody>
</table>

Source: NSF