Planning for Graduate School and the Physics GRE

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Peter Persans

Grad school or employment?

- Assess your interests, strengths, weaknesses this summer.
- Identify career fields that interest you. (Talk to friends. Talk to faculty. Go to career fairs. See a career counselor.)
- Select courses and research for your senior year that help you develop a resume and knowledge in your interest area.

- Grad school if you have a compelling reason.
- Employment is a good way to start your life after college.

Does graduate school make sense for you?

- Why do you want to go to graduate school?
  - Good reasons:
    - You are enthusiastic about some field or career and graduate school is the path to that career.
    - You want to understand the world at a deeper level.
  - Bad reasons:
    - You are good at academics.
    - You are scared of going out into the world and this is a way to put it off.

Graduate school process - timing

- Have a good undergraduate record
  - academics + research experience or other serious responsibilities
- This Summer – investigate schools and prepare for PGRE
- Nov-Jan 1 – application deadlines for Sept entry
  - Letters of recommendation from 3 faculty
  - Physics GRE (for Physics/Astro) in Oct or Nov
  - General GRE (important for other fields than Physics) in early autumn
- Their offers to you by ~March 15
- Your response to them by April 15

Fields other than Physics

- About 1/3 of our majors go to graduate school in fields other than Physics or Astronomy.
  - Geophysics, **Materials**, Earth Science, Meteorology,Oceanography, **Computer Science**, **Mathematics**, Aero, Mech E, EE, Optical Sciences
  - Law, Seminary, Economics, Psychology, Philosophy, Architecture
- Application emphasis will be different.
  - In many engineering fields, there are few TA's, so you must contact faculty in the program to secure a Research Assistantship

Preparation

- In order to be competitive for programs other than Physics, you should demonstrate interest and capability in that field through:
  - Junior/Senior level coursework in that field
  - Research or development participation
  - Strong letters of support

Getting information on grad departments

- Your faculty
- Rankings: www.phds.org, National Research Council, USNWR(?)
- AIP Graduate Programs in Physics and Astronomy (detailed information in standard format)
- Department Web sites
- Investigate faculty activity using Web of Science citation reports

Tests you need for grad school

- For **Physics and Astronomy graduate programs** you need the **Physics Subject GRE** and the general GRE.
- For Materials, Mech E, EE, Applied Physics, Optics, Math, Biophysics, Geophysics you only need the general GRE.

The General GRE

- A lot like the SAT, but with a higher verbal standard.
- Very elementary math that you may have lost touch with – doing well is important for engineering grad students – practice for this.
- A writing exam

Why do you need the Physics GRE?

- Admission to most well regarded graduate programs in Physics and Astronomy requires it.
- The Physics GRE weighs heavily for most schools – especially if you are not from a large or well-known undergraduate program

Important acceptance considerations

- GPA:
  - below 3.6 hinders acceptance into top-ranked programs
- Physics GRE:
  - below 800 hinders acceptance to top-ranked programs
  - below 600 hinders acceptance into well-regarded programs.
- General GRE:
  - Not an important admissions factor for most Physics programs for which Physics GRE is expected. Some schools require it and minimum requirements must be met.
  - Elite programs use them to distinguish between applicants with near perfect PGRE's. and 4.0 GPA's.
- Research:
  - Notable research with good letters and a publication or meeting presentation helps significantly
- Letters of recommendation
  - Good letters from faculty/researchers who have a track record helps significantly.
- Knowing/contacting people at the target institution can help.

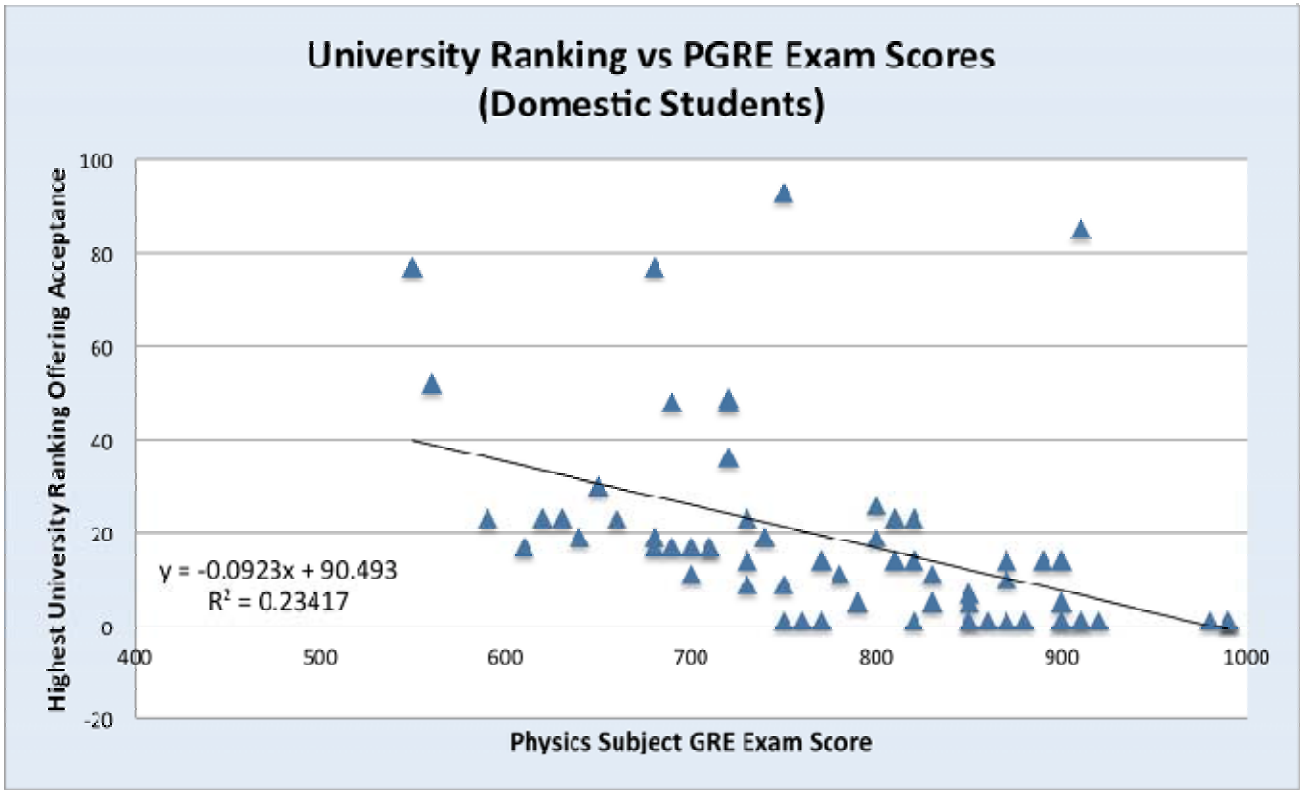
Are you competitive?

- For top ranked programs: GPA>3.7, PGRE>800, + Notable research and very strong letters
- For well-regarded program: GPA>3.5, PGRE>700, +research and strong letters
  - Admission committee will actually read your transcript and letters
- If your GPA is lower, you need great letters and a good story. PGRE usually cannot save an otherwise poor record.

Examples of the ranking of graduate Physics programs

- "Top ten" examples
  - #1 [Harvard, Princeton, Cal Tech, , UC Berkeley], Stanford, MIT, Cornell, Illinois, UCSB, Chicago
- "Next ten" examples
  - U Penn, Yale, Wisconsin, Michigan, UCLA, U Washington, UCSD, UT Austin, Columbia, Maryland, Stony Brook
- ~30 – Northwestern, Carnegie Mellon, Brown, Rochester, NYU, U Minnesota

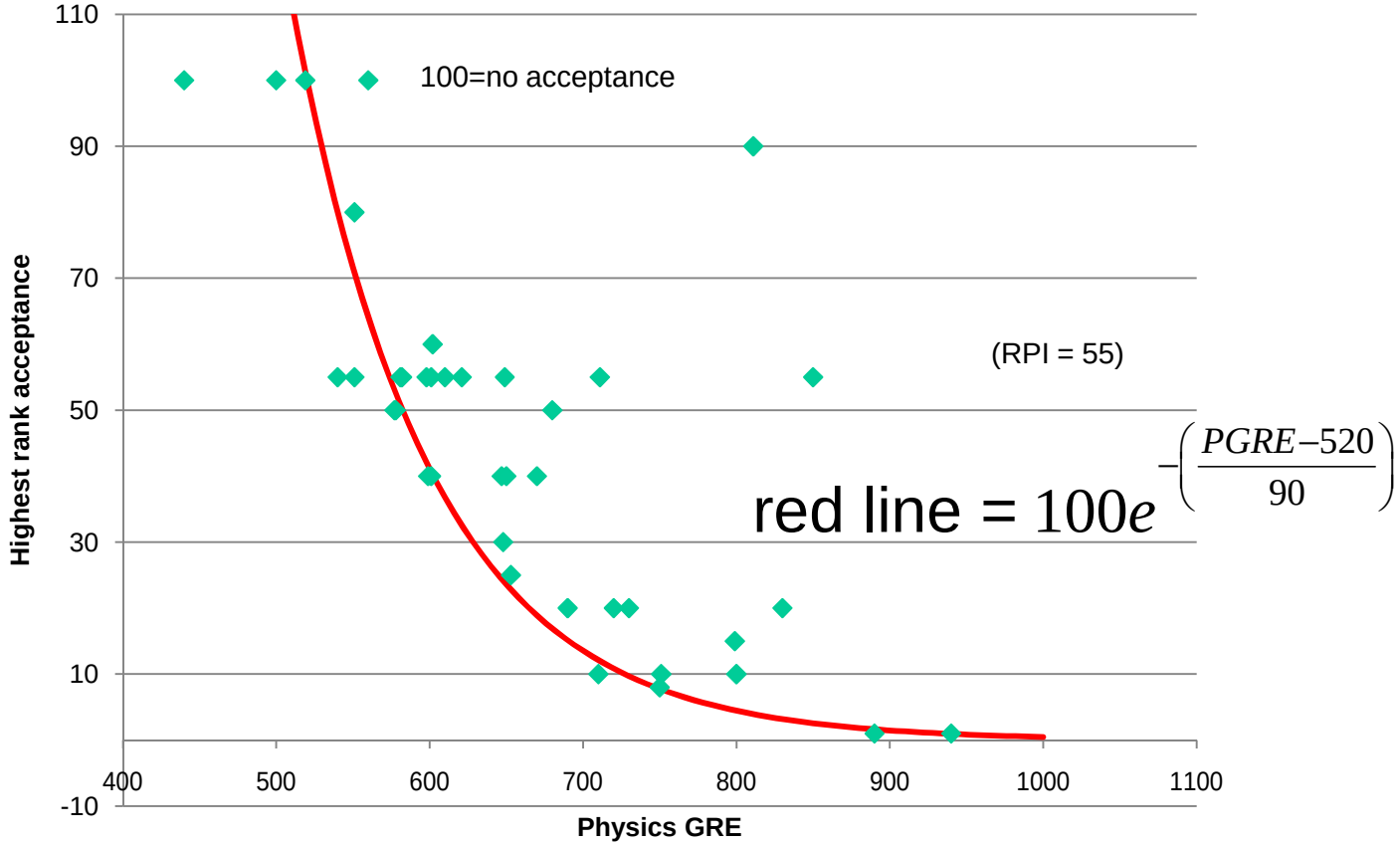
A chart from physicsgre.com



- Physics GRE score (>700) is necessary but not sufficient for admission to well-regarded program. (>750 for top ten.)
- Physics GRE below 600 seriously decreases chances of getting into a well-regarded program.

Best graduate program ranking vs PGRE

(RPI students – Physics grad programs only)

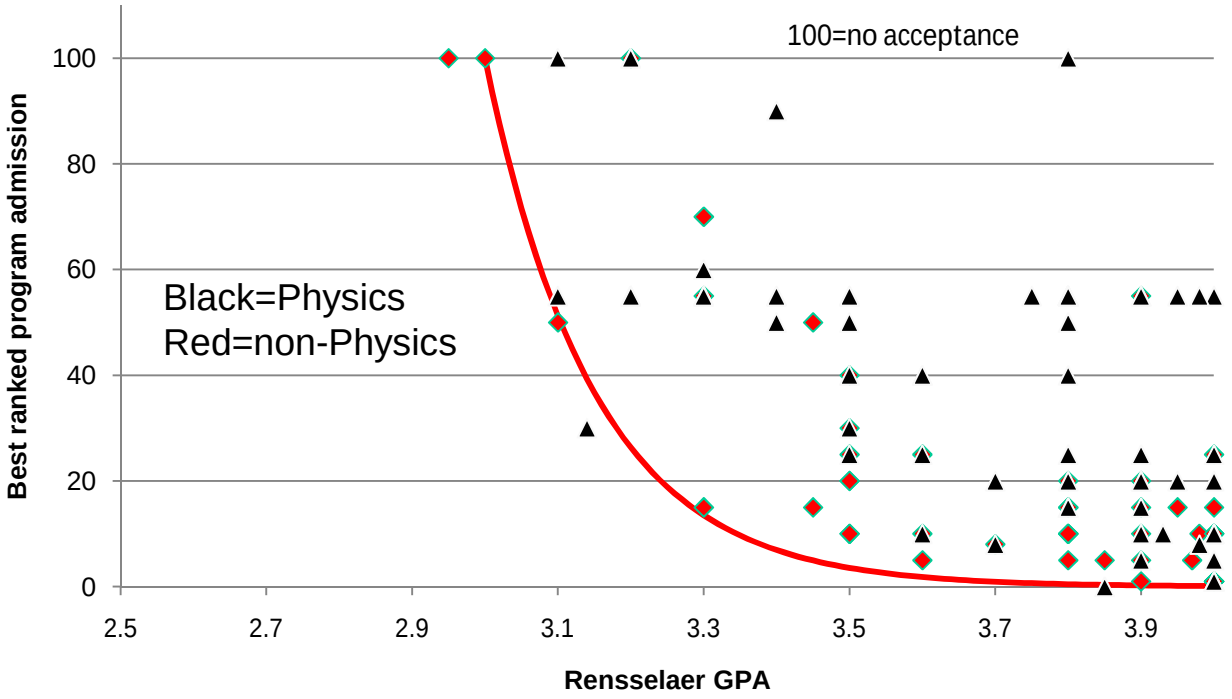


- Scatter means that PGRE is not everything.
- Lower bound cut-off means that score below certain value hinders acceptance into higher ranked schools.
- Score below 550 ~ acceptance very unlikely.

Recent RPI Classes – Grad Schools

851<GRE	Harvard, Stanford, Cornell, MIT, Cal Tech, UCSB, Illinois, Oxford, RPI
751<GRE <850	UT Austin, UC San Diego, Cambridge, Cornell, Chicago, Oxford, Columbia, UCSB, Illinois, RPI
651<GRE <750	Cornell (Astro), RPI, U Minn, U Wash, Stony Brook, UC Irvine, RPI
601<GRE <650	RPI, NYU, Dartmouth, Brandeis
550<GRE<600	RPI, VA Tech, UCF (optics), U Conn
None (solid grades, solid research, great letters)	RPI, [Harvard, Stanford] (Applied Physics); [Harvard, Chicago, Cornell] (biophysics), Penn State (materials), [Oregon, CMU, MIT] (comp sci), [UCLA, Scripps, U Washington] (geophysics), [Harvard, Cornell, UCLA, UCSD, UCSB, Illinois, CMU] (ECE), [Purdue, GATech, Maryland] (Aero), JHU (education), [Columbia, MIT, Wisconsin] (Nucl Eng).

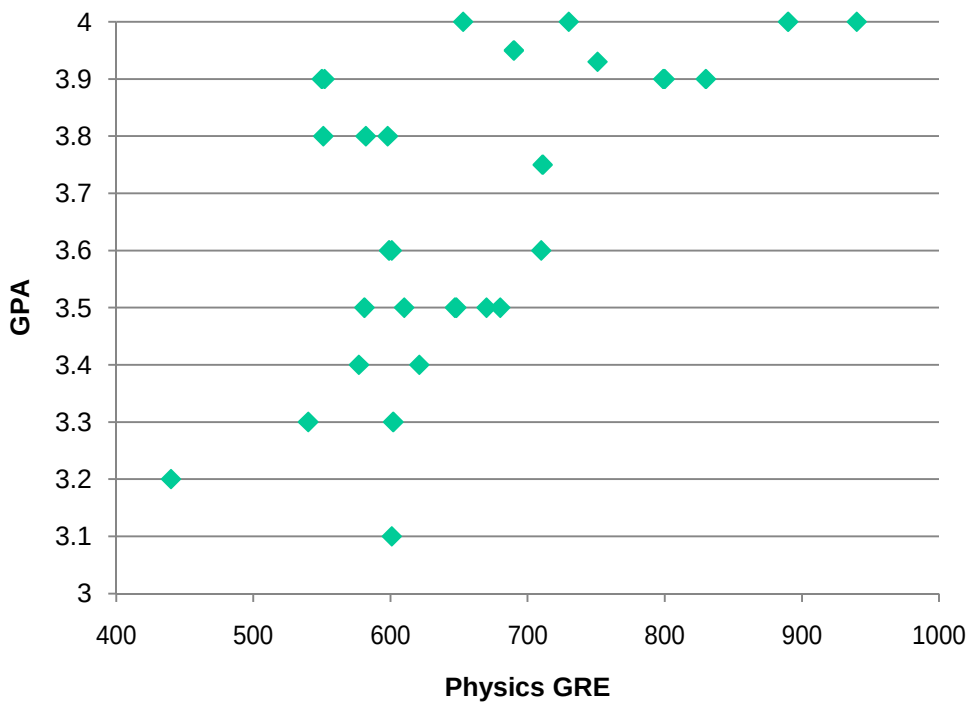
Best graduate program ranking vs GPA
(RPI Physics students – all grad program fields)



- Scatter means that GPA is a necessary but not sufficient condition for acceptance to higher ranked schools.
- No acceptance anywhere for GPA below 3.1
- Top 10 programs usually require 3.6+ (with other strengths).

Physics GRE – GPA correlation

(RPI undergrads only)



- High GPA does not automatically lead to high PGRE.
- The lower the GPA, the lower the best PGRE performance.

The Physics GRE Test

When should you take the Physics GRE?

- October/November about one year before you hope to enter grad school.
- Earlier is ok.

Is there a point to preparing?

- YES!
- Practice alone will probably raise your score by over 50 pts.
- A combination of practice and study can raise your score by hundreds of points.
- This exam tests specific knowledge as well as problem solving and logic.
- You should have basic relationships and formulas memorized so that you don’t have to think to recall or derive them.

Information on the Exam

- www.ets.org – Why not get information directly from the source? It will be correct.
- en.wikipedia.org/wiki/**GRE_Physics**_Test – Overview and useful links.
- http://blogs.discovermagazine.com/cosmicvariance/2009/10/22/an-inside-look-at-the-physics-gre/ - A letter from a person who wrote problems and edited problems for exams.
- http://grephysics.net/ans/ - A wiki-edited solution for all released problems with unedited comments.
- Physicsgre.com – discussion forum, statistics, answers, exams…

The exam content
100 questions! – 170 minutes!

1.CLASSICAL MECHANICS: 20%
(such as kinematics, Newton's laws, work and energy, oscillatory motion, rotational motion about a fixed axis, dynamics of systems of particles, central forces and celestial mechanics, three-dimensional particle dynamics, Lagrangian and Hamiltonian formalism, noninertial reference frames, elementary topics in fluid dynamics)
2.ELECTROMAGNETISM: 18%
(such as electrostatics, currents and DC circuits, magnetic fields in free space, Lorentz force, induction, Maxwell's equations and their applications, electromagnetic waves, AC circuits, magnetic and electric fields in matter)
3.OPTICS AND WAVE PHENOMENA: 9%
(such as wave properties, superposition, interference, diffraction, geometrical optics, polarization, Doppler effect)
4.THERMODYNAMICS AND STATISTICAL MECHANICS: 10%
(such as the laws of thermodynamics, thermodynamic processes, equations of state, ideal gases, kinetic theory, ensembles, statistical concepts and calculation of thermodynamic quantities, thermal expansion and heat transfer)
5.QUANTUM MECHANICS: 12%
(such as fundamental concepts, solutions of the Schrödinger equation (including square wells, harmonic oscillators, and hydrogenic atoms), spin, angular momentum, wave function symmetry, elementary perturbation theory)
6.ATOMIC PHYSICS: 10%
(such as properties of electrons, Bohr model, energy quantization, atomic structure, atomic spectra, selection rules, black-body radiation, x-rays, atoms in electric and magnetic fields)
7.SPECIAL RELATIVITY: 6%
(such as introductory concepts, time dilation, length contraction, simultaneity, energy and momentum, four-vectors and Lorentz transformation, velocity addition)
8.LABORATORY METHODS: 6%
(such as data and error analysis, electronics, instrumentation, radiation detection, counting statistics, interaction of charged particles with matter, lasers and optical interferometers, dimensional analysis, fundamental applications of probability and statistics)
9.SPECIALIZED TOPICS: 9%
Nuclear and Particle physics (e.g., nuclear properties, radioactive decay, fission and fusion, reactions, fundamental properties of elementary particles), Condensed Matter (e.g., crystal structure, x-ray diffraction, thermal properties, electron theory of metals, semiconductors, superconductors), Miscellaneous (e.g., astrophysics, mathematical methods, computer applications)

A different type of exam

- This is a different type of exam from most physics exams that you have taken as an undergraduate.
- Many multiple choice problems that challenge your understanding and facility with basic physics.
- Doing well shows:
  - Your command of basic physics and relationships.
  - Your discipline in preparing for such an exam.
  - Your ability to think fast and logically.
- Doing well does not show your depth, other measures are needed for that.

The exam level

- 75% of the exam is at the Halliday and Resnick level.
- Scoring 75% correct could earn a near perfect score! (Scoring depends on the exam – difficulty is evaluated every year.)

Examples – remembering relationships and doing simple calculation

The coefficient of static friction between a small coin and the surface of a turntable is 0.30. The turntable rotates at 33.3 revolutions per minute. What is the maximum distance from the center of the turntable at which the coin will not slide?

(A) 0.024 m
(B) 0.048 m
(C) 0.121 m
(D) 0.242 m
(E) 0.484 m

$Ans: D$

$$F_c = ma = m\omega^2 r$$

$$F_{crit} = \mu g m$$

$$r = \frac{\mu g}{\omega^2} = \frac{0.3 \bullet 9.8}{(2\pi \bullet 33.3/60)^2}$$

Examples – remembering facts

A three-dimensional harmonic oscillator is in thermal equilibrium with a temperature reservoir at temperature *T*. The average total energy of the oscillator is

(A) ½ *kT*

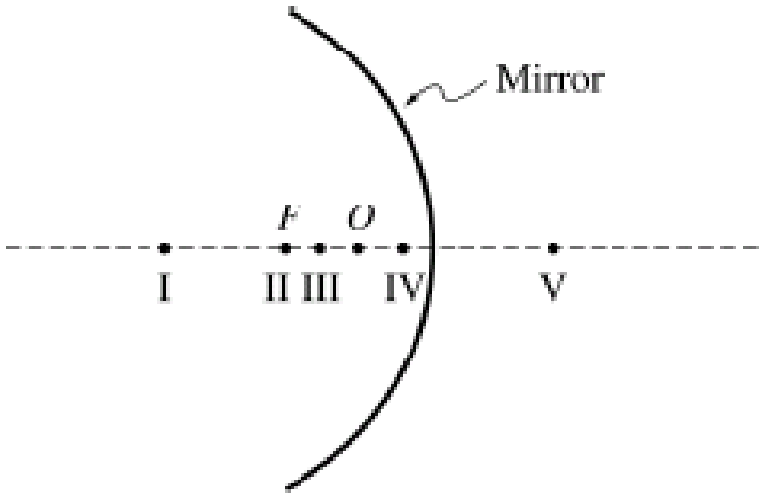
(B) *kT*

(C) 3/2 *kT*

(D) 3*kT*

(E) 6*kT*

Ans:D –
3 rotational and 3 translational degrees of freedom with kT/2 for each



2. A spherical, concave mirror is shown in the figure above. The focal point F and the location of the object O are indicated. At what point will the image be located?

(A) I
(B) II
(C) III
(D) IV
(E) V

Ans: E
1/f=1/o+1/i
1/i=1/f-1/o and o is smaller than f
So i is negative.

An 8-centimeter-diameter by 8-centimeter-long NaI(Tl) detector detects gamma rays of a specific energy from a point source of radioactivity. When the source is placed just next to the detector at the center of the circular face, 50 percent of all emitted gamma rays at that energy are detected. If the detector is moved to 1 meter away, the fraction of detected gamma rays drops to

(A) 10^{-4}

(B) 2×10^{-4}

(C) 4×10^{-4}

(D) $8\pi \times 10^{-4}$

(E) $16\pi \times 10^{-4}$

Everything that enters the front surface of the detector is counted

$$\text{Fraction} \cong \frac{\pi d^2 / 4}{4\pi r^2} = \frac{d^2}{16 r^2} = \frac{64 \times 10^{-4}}{16} = 4 \times 10^{-4}$$

Exam Strategy

- Answer every question for which you can eliminate one or more possible solutions (including those for which you know the answer!).
  - Plan on leaving at least ½ hour at the end to review every answer.
- More detailed suggestions
  - Go through the exam once, answering every question you can do quickly, mark the problems to which you need to return.
  - Return through the exam doing the problems you think you can do with reasonable work, using about <5 min per problem.
  - Then tackle the harder problems, but do not sacrifice care with the easy ones in favor of the hard ones. Every problem counts equally.
- Thoughtfully and thoroughly review!!!!!

Summer study strategy

- Set a realistic schedule.
- See me or go to ets.org for practice tests.
- Take one of the example exams under test conditions.
  - Take the whole test.
  - Score yourself honestly.
  - Note the problems for which you have forgotten formulas. Look up formulas.
  - The AP Physics formula sheet is good for review of basic material.
  - Read relevant material. (Mostly Halliday-Resnick-Krane.)
- Take the next example exam.
- Don’t “rinse” but do repeat.
- Join me in September to discuss and practice for the November exam.

False Exam Myths

- You can do well on the Physics GRE just through dimensional analysis.
- You can do well on the GRE by just eliminating illogical solutions.
- You can do well on the GRE just using asymptotic analysis.

True Exam Myths

- Upper level material is not essential for doing well. You can do well on the Physics GRE just by knowing freshman and sophomore level Physics cold.
  - Many students focus on upper level material and forget to review basics.
- Practice alone will raise your score significantly.
- Study matters.
- The GRE is not needed for foreign study. When GRE is not required, letters and connections are <u>much</u> more important.