Preparing for the Physics GRE: Day 1 Introduction and Strategies

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Who Am I?

- Daniel Citron
- dtc65@cornell.edu
- 5th Year Physics Grad Student
- (Study nonlinear dynamics and networks)
- My credentials:
  - Took the test three times
  - Got the score I wanted the third time
  - (You should not need to make the same mistakes as me)

Why Take the Physics GRE?

- You’re applying to physics graduate school
- … and that’s it.
- The test does not really evaluate your merits as a physicist or scientist
- Focuses on problem solving, calculation, basic physics
- Not the most important part of your application
- But, you might as well do as well as you can

Test Format

- No calculators allowed, only pencils
- Scratch paper and "Table of Information" provided
  100 Multiple-choice questions, 170 minutes
- ~ **100 seconds** per question
- Much of the test format requires racing this clock

Test Format: Table of Information

- Provided at exam
- Includes:
  - Constants with units
  - Powers of 10 prefixes
  - Rotational inertia
- Familiarize yourself before taking the test

TABLE OF INFORMATION

Rest mass of the electron	$m_e = 9.11 \times 10^{-31}$ kg
Magnitude of the electron charge	$e = 1.60 \times 10^{-19}$ C
Avogadro's number	$N_A = 6.02 \times 10^{23}$
Universal gas constant	$R = 8.31$ J/(mol • K)
Boltzmann's constant	$k = 1.38 \times 10^{-23}$ J/K
Speed of light	$c = 3.00 \times 10^{8}$ m/s
Planck's constant	$h = 6.63 \times 10^{-34}$ J • s $= 4.14 \times 10^{-15}$ eV • s
	$\hbar = h/2\pi$
	$hc = 1240$ eV • nm
Vacuum permittivity	$\epsilon_0 = 8.85 \times 10^{-12}$ C^2/(N • m^2)
Vacuum permeability	$\mu_0 = 4\pi \times 10^{-7}$ T • m/A
Universal gravitational constant	$G = 6.67 \times 10^{-11}$ m^3/(kg • s^2)
Acceleration due to gravity	$g = 9.80$ m/s^2
1 atmosphere pressure	1 atm $= 1.0 \times 10^5$ N/m^2 $= 1.0 \times 10^5$ Pa
1 angstrom	1Å $= 1 \times 10^{-10}$ m $= 0.1$ nm

Test Format - Topics

- Classical mechanics (20%)
- Electromagnetism (18%)
- Optics and waves (9%)
- Thermodynamics and statistical mechanics (10%)
- Quantum mechanics (12%)
- Special relativity (6%)
- Laboratory methods (6%)
- Atomic physics (10%)
- Other topics: nuclear physics, particle physics, crystals, semiconductors (9%)

Test Format

- Bad news:
  - Test covers a ton of different topics
  - Need to perform calculations very quickly
  - (Also, it's at early o'clock in the morning)
- Good news:
  - Most material relates to topics covered in the first two years
  - Only some memorization is required (eg: Maxwell's equations)
  - There are tricks for making calculations simpler that don't require special knowledge

Course Format

- Meeting dates: **2/23, 3/1, 3/8, 3/15, 3/22**
  (possibly after spring break as well, as needed)
- **Tuesday 5:30-6:30 PM, Clark 294C**
- Today
  - Review Test Format
  - Resources for studying
  - Test-taking strategies
- This weekend
  - Take practice test **in real time**
- Next week
  - Review questions from practice test
  - (Can email me ahead of time so I can prepare)
  - Also review topics from test

Course Format

- Next four classes
  - Review topics as requested
  - Will emphasize topics such that we learn to perform calculations required on the test
- Additionally:
  - Will provide paper copies of 4 other practice tests
  - Encourage you to take tests in real time on Saturday mornings **(830 AM)** following each course session (before you take the test for real)
  - This is the best way to know what you need to review
  - This is a skill that requires a little **practice**

Resources

- ETS website:
  - http://www.ets.org/gre/subject/about/content/physics
- Conquering the Physics GRE
  - Comprehensive overview of material
  - Includes lists of things to memorize
  - Focuses on physics knowledge, not on strategy
  - (Expensive)
- GREPhysics (not great, last updated 6 years ago…)
  - http://grephysics.net/ans/

Recommended Textbooks

- Your favorite freshmen general physics book
- Classical Mechanics, Taylor
- Quantum Mechanics, Griffiths
- Electricity and Magnetism, Griffiths
  - Also for intro to special relativity
- Mathematical Methods, Boas
- Quantum Physics, Eisberg and Resnick
  - Atomic physics, nuclear physics, blackbody radiation…

Tricks

Tricks: Always guess

- If you can eliminate at least one answer, guess
- Correct answers worth 1 point
- Incorrect answers worth -.25 points
- Totally random guess:
  - .2*1 + .8*(-.25) = 0
  - 0 expected score gain
- Random guess, eliminating one answer:
  - .25*1 + .75*(-.25) = .0625
  - 1/16 of a point expected score gain
  - (Better than nothing)
- **All test-taking strategies that will make the Physics GRE easier depend on your ability to use intuition to immediately eliminate one or more answers.**

Tricks: Orders of Magnitude

$$e = 3 = \pi = 4 = 10^{1/2}$$

- Arithmetic does not need to be exact
- Save time by avoiding digits larger than 1 or 2.
- Collect orders of magnitude
- Numerical answers often differ by enough that you avoid rounding errors this way

Tricks: Orders of Magnitude

Which of the following is most nearly the mass the Earth? (The radius of the Earth is about 6.4×10^6 meters.)

(A) 6×10^{24} kg

(B) 6×10^{27} kg

(C) 6×10^{30} kg

(D) 6×10^{33} kg

(E) 6×10^{36} kg

Hint: $G = 6.67 \times 10^{-11}$ meter^3/(kilogram second^2)

Tricks: Orders of Magnitude

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$$mg = \frac{GMm}{r^2}$$

$$M = \frac{gr^2}{G} = \frac{6^2 \cdot 10 \cdot (10^6)^2}{6 \cdot 10^{-11}}$$

$$M = 6 \cdot 10^{12+1+11} = 6 \cdot 10^{24}$$

Tricks: Dimensional analysis

- Can easily eliminate many possible answers because they have incorrect dimensions
- Quick example (you have 10 seconds to answer)

Q: How tall am I?

(A): 5 dollars

(B): 12 N

(C): 70 Gpa

(D): 6 feet

(E): 14 Ω

Tricks: Dimensional analysis

- A slightly harder question:

10. A massless spring with force constant k launches a ball of mass m. In order for the ball to reach a speed v, by what displacement s should the spring be compressed?

(A) $s = v\sqrt{\frac{k}{m}}$

(B) $s = v\sqrt{\frac{m}{k}}$

(C) $s = v\sqrt{\frac{2k}{m}}$

(D) $s = v\frac{m}{k}$

(E) $s = v^2\frac{m}{2k}$

Tricks: Dimensional analysis

- $[v] = m/s$
- $[k] = N/m = kg/s^2$
- $[m] = kg$
- $[k/m] = 1/s^2$
- $[answer] = m$

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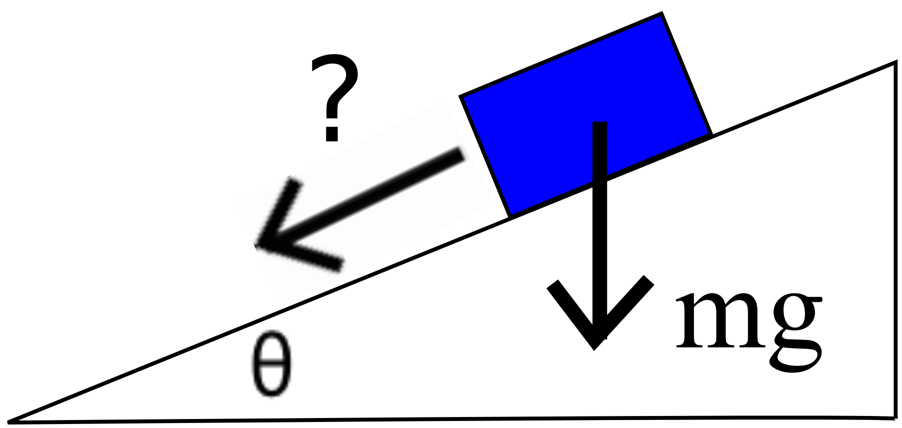
(E) $s = v^2\frac{m}{2k}$

- $[A] = m/s^2$
- **$[B] = m$**
- $[C] = m/s^2$
- $[D] = m/s^3$
- $[E] = m^2$

Tricks: Taking Limits

- Examine answers and check to see if they make sense in certain limits
- Quick example:

What is the force on the block in the direction parallel to the ramp?



(A) mg sin(θ)

(B) mg cos(θ)

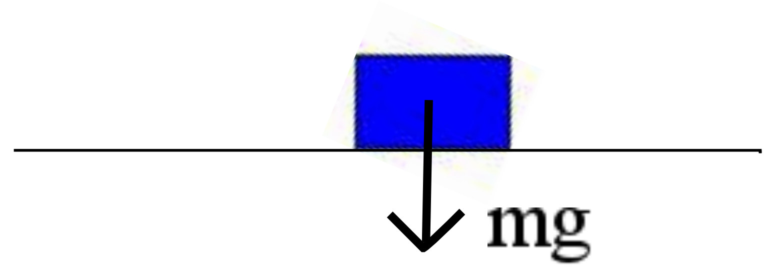
(C) mg tan(θ)

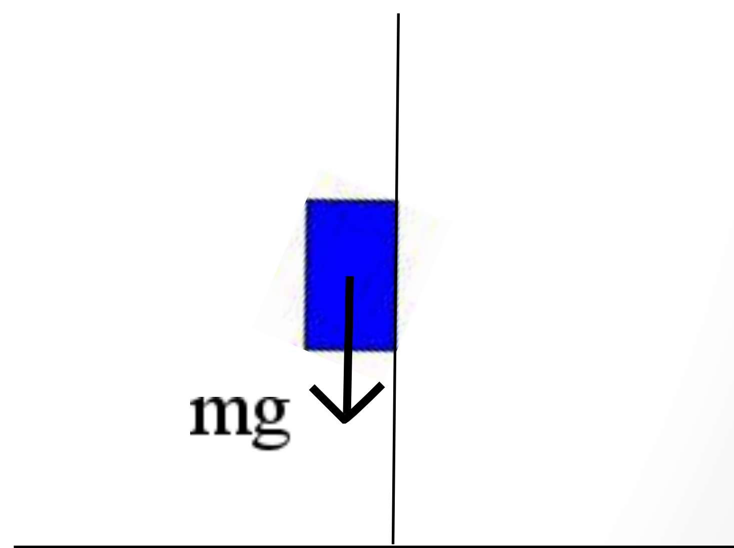
Tricks: Taking Limits

(A) mg sin(θ)
(B) mg cos(θ)
(C) mg tan(θ)

Examine answers and check to see if they make sense in certain limits

- Let θ -> 0
- Force goes to 0,
  like sin(θ) and tan(θ)

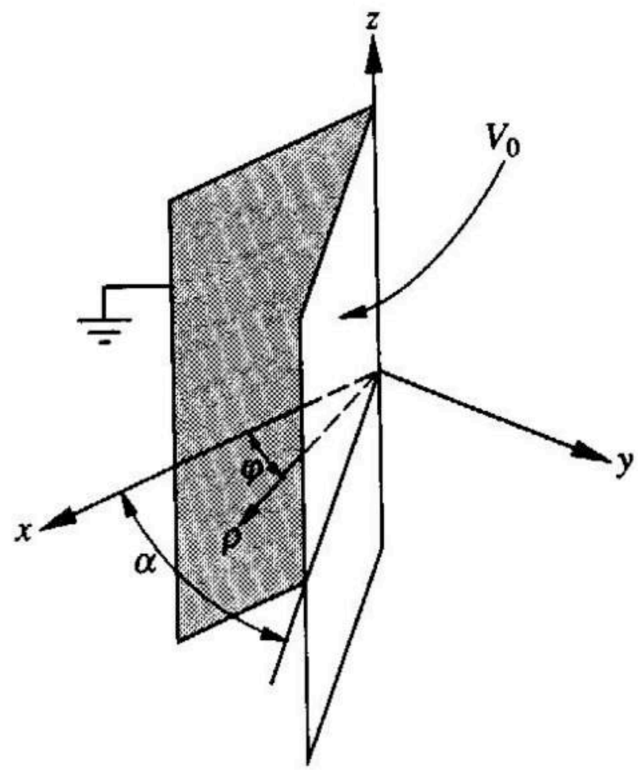




- Let θ -> π/2
- Force goes to mg

Answer: mg sin(θ)

Tricks: Taking Limits



12. Two large conducting plates form a wedge of angle α as shown in the diagram above. The plates are insulated from each other; one has a potential V_0 and the other is grounded. Assuming that the plates are large enough so that the potential difference between them is independent of the cylindrical coordinates z and ρ, the potential anywhere between the plates as a function of the angle φ is

- Look at potential at:
  - $\phi \to 0$
  - $\phi \to \alpha$
- Which answers make sense? Which answers do not?

(A) $\dfrac{V_0}{\alpha}$

(B) $\dfrac{V_0 \varphi}{\alpha}$

(C) $\dfrac{V_0 \alpha}{\varphi}$

(D) $\dfrac{V_0 \varphi^2}{\alpha}$

(E) $\dfrac{V_0 \alpha}{\varphi^2}$