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

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rest mass of the electron</td>
<td>$m_e = 9.11 \times 10^{-31} \text{ kg}$</td>
</tr>
<tr>
<td>Magnitude of the electron charge</td>
<td>$e = 1.60 \times 10^{-19} \text{ C}$</td>
</tr>
<tr>
<td>Avogadro’s number</td>
<td>$N_A = 6.02 \times 10^{23}$</td>
</tr>
<tr>
<td>Universal gas constant</td>
<td>$R = 8.31 \text{ J/(mol} \cdot \text{K)}$</td>
</tr>
<tr>
<td>Boltzmann’s constant</td>
<td>$k = 1.38 \times 10^{-23} \text{ J/K}$</td>
</tr>
<tr>
<td>Speed of light</td>
<td>$c = 3.00 \times 10^8 \text{ m/s}$</td>
</tr>
<tr>
<td>Planck’s constant</td>
<td>$h = 6.63 \times 10^{-34} \text{ J} \cdot \text{s} = 4.14 \times 10^{-15} \text{ eV} \cdot \text{s}$</td>
</tr>
<tr>
<td></td>
<td>$\hbar = h/2\pi$</td>
</tr>
<tr>
<td>$hc$</td>
<td>$1240 \text{ eV} \cdot \text{nm}$</td>
</tr>
<tr>
<td>Vacuum permittivity</td>
<td>$\varepsilon_0 = 8.85 \times 10^{-12} \text{ C}^2/(\text{N} \cdot \text{m}^2)$</td>
</tr>
<tr>
<td>Vacuum permeability</td>
<td>$\mu_0 = 4\pi \times 10^{-7} \text{ T} \cdot \text{m/A}$</td>
</tr>
<tr>
<td>Universal gravitational constant</td>
<td>$G = 6.67 \times 10^{-11} \text{ m}^3/(\text{kg} \cdot \text{s}^2)$</td>
</tr>
<tr>
<td>Acceleration due to gravity</td>
<td>$g = 9.80 \text{ m/s}^2$</td>
</tr>
<tr>
<td>1 atmosphere pressure</td>
<td>$1 \text{ atm} = 1.0 \times 10^5 \text{ N/m}^2 = 1.0 \times 10^5 \text{ Pa}$</td>
</tr>
<tr>
<td>1 angstrom</td>
<td>$1 \text{ Å} = 1 \times 10^{-10} \text{ m} = 0.1 \text{ nm}$</td>
</tr>
</tbody>
</table>
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:
  • \[.2 \times 1 + .8 \times (-.25) = 0\]
  • 0 expected score gain
• Random guess, eliminating one answer:
  • \[.25 \times 1 + .75 \times (-.25) = .0625\]
  • 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

\[ e = 3 = \pi = 4 = 10^{\frac{1}{2}} \]

- 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 of the Earth? (The radius of the Earth is about $6.4 \times 10^6$ meters.)

(A) $6 \times 10^{24}$ kg
(B) $6 \times 10^{27}$ kg
(C) $6 \times 10^{30}$ kg
(D) $6 \times 10^{33}$ kg
(E) $6 \times 10^{36}$ kg

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

Which of the following is most nearly the mass of the Earth? (The radius of the Earth is about 6.4 \times 10^6 \text{ meters}.)

(A) \(6 \times 10^{24} \text{ kg}\)

(B) \(6 \times 10^{27} \text{ kg}\)

(C) \(6 \times 10^{30} \text{ kg}\)

(D) \(6 \times 10^{33} \text{ kg}\)

(E) \(6 \times 10^{36} \text{ kg}\)

\[
m g = \frac{G M m}{r^2}
\]

\[
M = \frac{g r^2}{G} = \frac{6^2 \cdot 10 \cdot (10^6)^2}{6 \cdot 10^{-11}}
\]

\[
M = 6 \cdot 10^{12+1+11} = 6 \cdot 10^{24}
\]
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) $s = v \sqrt{2k}$

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

(E) $s = v^2 \frac{m}{2k}$
Tricks: Dimensional analysis

- \([v] = \text{m/s}\)
- \([k] = \text{N/m} = \text{kg/s}^2\)
- \([m] = \text{kg}\)
- \([k/m] = \text{1/s}^2\)
- \([\text{answer}] = \text{m}\)
- \([A] = \text{m/s}^2\)
- \([B] = \text{m}\)
- \([C] = \text{m/s}^2\)
- \([D] = \text{m/s}^3\)
- \([E] = \text{m}^2\)

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?

\[ s = v \sqrt{\frac{k}{m}} \]

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

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

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

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

(E) \(s = v^2 \frac{m}{2k}\)
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(\theta)
  (B) mg \cos(\theta)
  (C) mg \tan(\theta)
Tricks: Taking Limits

(A) $mg \sin(\theta)$
(B) $mg \cos(\theta)$
(C) $mg \tan(\theta)$

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

- Let $\theta \to 0$
- Force goes to 0, like $\sin(\theta)$ and $\tan(\theta)$

- Let $\theta \to \pi/2$
- Force goes to $mg$

Answer: $mg \sin(\theta)$
Tricks: Taking Limits

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

(A) $\frac{V_0}{\alpha}$
(B) $\frac{V_0 \phi}{\alpha}$
(C) $\frac{V_0 \alpha}{\phi}$
(D) $\frac{V_0 \phi^2}{\alpha}$
(E) $\frac{V_0 \alpha}{\phi^2}$

12. Two large conducting plates form a wedge of angle $\alpha$ 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 $\rho$, the potential anywhere between the plates as a function of the angle $\phi$ is