Preparing for the GRE: Strategies for Success

Welcome – we'll get started soon

- Dial in or use your computer's microphone and speakers.
- Submit questions via the Questions panel on the right.
- This session is being recorded.
- The recording will be sent to you via a follow up email.

Make sure to sign up to receive information about future APS webinars at:

www.aps.org/careers/guidance/webinars

Preparing for the Physics GRE: Strategies for Success

Yoni Kahn

March 7, 2017

Physics GRE: the basics

- 100 questions, 170 minutes
- Multiple choice, 5 answers
- Standard (and less standard) undergrad physics

Classical mech: 20%
E+M: 18%
Optics/waves: 9%
Thermo/stat mech: 10%
Quantum: 12%

~70% core subjects

Atomic physics: 10%
Special relativity: 6%
Lab methods: 6%
Specialized topics: 9%

~30% "grab bag"

Reference materials

- “Conquering the Physics GRE” - available on Amazon
  - review material and practice questions for each subject area
  - 3 full-length practice tests
  - tips and tricks specific to Physics GRE

- ETS practice material
  - most recent (2008) at www.ets.org
  - previous (2001, 1996, 1992, 1986) at grephysics.net
  - 2001 and 2008 are most representative of current test

This **is** a test of outside knowledge:
you will need to memorize some things!

Tips and Tricks: Derive, don't memorize!

ETS 2001 #3

3. A satellite of mass m orbits a planet of mass M in a circular orbit of radius R. The time required for one revolution is

(A) independent of M
(B) proportional to $\sqrt{m}$
(C) linear in R
(D) proportional to $R^{3/2}$
(E) proportional to R^2

Tips and Tricks: Derive, don't memorize!

ETS 2001 #3

3. A satellite of mass m orbits a planet of mass M in a circular orbit of radius R. The time required for one revolution is

(A) independent of M

(B) proportional to $\sqrt{m}$

(C) linear in R

(D) proportional to $R^{3/2}$

(E) proportional to R^2

Formula for period of circular orbit?

Tips and Tricks: Derive, don’t memorize!

ETS 2001 #3

3. A satellite of mass m orbits a planet of mass M in a circular orbit of radius R. The time required for one revolution is

(A) independent of M
(B) proportional to $\sqrt{m}$
(C) linear in R
(D) proportional to $R^{3/2}$
(E) proportional to R^2

Formula for period of circular orbit?

OR: uniform circular motion + Newton’s law of gravity

derive the formula you need

Tips and Tricks: Derive, don't memorize!

ETS 2001 #3

3. A satellite of mass m orbits a planet of mass M in a circular orbit of radius R. The time required for one revolution is

(A) independent of M

(B) proportional to $\sqrt{m}$

(C) linear in R

(D) proportional to $R^{3/2}$

(E) proportional to R^2

$$F_{\text{centripetal}} = \frac{mv^2}{R}$$

Tips and Tricks: Derive, don't memorize!

ETS 2001 #3

3. A satellite of mass m orbits a planet of mass M in a circular orbit of radius R. The time required for one revolution is

(A) independent of M

(B) proportional to $\sqrt{m}$

(C) linear in R

(D) proportional to $R^{3/2}$

(E) proportional to R^2

$$F_{\text{centripetal}} = \frac{mv^2}{R}$$

$$F_{\text{grav}} = \frac{GmM}{R^2}$$

Tips and Tricks: Derive, don't memorize!

ETS 2001 #3

3. A satellite of mass m orbits a planet of mass M in a circular orbit of radius R. The time required for one revolution is

(A) independent of M
(B) proportional to $\sqrt{m}$
(C) linear in R
(D) proportional to $R^{3/2}$
(E) proportional to R^2

$$F_{\text{centripetal}} = \frac{mv^2}{R} \qquad F_{\text{grav}} = \frac{GmM}{R^2}$$

$$F_{\text{centripetal}} = F_{\text{grav}} \implies v = \sqrt{\frac{GM}{R}}$$

Tips and Tricks: Derive, don't memorize!

ETS 2001 #3

3. A satellite of mass m orbits a planet of mass M in a circular orbit of radius R. The time required for one revolution is

(A) independent of M
(B) proportional to $\sqrt{m}$
(C) linear in R
(D) proportional to $R^{3/2}$
(E) proportional to R^2

$$F_{\text{centripetal}} = F_{\text{grav}} \implies v = \sqrt{\frac{GM}{R}}$$

$$T = \frac{2\pi R}{v} \propto R^{3/2}$$

Tips and Tricks: Derive, don't memorize!

ETS 2001 #3

3. A satellite of mass m orbits a planet of mass M in a circular orbit of radius R. The time required for one revolution is

(A) independent of M
(B) proportional to $\sqrt{m}$
(C) linear in R
(D) proportional to $R^{3/2}$
(E) proportional to R^2

Kepler's Third Law!

$$F_{\text{centripetal}} = F_{\text{grav}} \implies v = \sqrt{\frac{GM}{R}}$$

$$T = \frac{2\pi R}{v} \propto R^{3/2}$$

Tips and Tricks: Derive, don't memorize!

ETS 2001 #62

62. A nonrelativistic particle with a charge twice that of an electron moves through a uniform magnetic field. The field has a strength of $\pi/4$ tesla and is perpendicular to the velocity of the particle. What is the particle's mass if it has a cyclotron frequency of 1,600 hertz?

(A) 2.5×10^{-23} kg
(B) 1.2×10^{-22} kg
(C) 3.3×10^{-22} kg
(D) 5.0×10^{-21} kg
(E) 7.5×10^{-21} kg

Your turn!

Numbers from front of test book:

$$e = 1.60 \times 10^{-19}\ \mathrm{C}$$

Tips and Tricks: Derive, don't memorize!

ETS 2001 #62

62. A nonrelativistic particle with a charge twice that of an electron moves through a uniform magnetic field. The field has a strength of $\pi/4$ tesla and is perpendicular to the velocity of the particle. What is the particle's mass if it has a cyclotron frequency of 1,600 hertz?

(A) 2.5×10^{-23} kg
(B) 1.2×10^{-22} kg
(C) 3.3×10^{-22} kg
(D) 5.0×10^{-21} kg
(E) 7.5×10^{-21} kg

$$F_{\text{centripetal}} = \frac{mv^2}{R}$$

$$F_B = qvB = 2evB$$

Tips and Tricks: Derive, don't memorize!

ETS 2001 #62

62. A nonrelativistic particle with a charge twice that of an electron moves through a uniform magnetic field. The field has a strength of $\pi/4$ tesla and is perpendicular to the velocity of the particle. What is the particle's mass if it has a cyclotron frequency of 1,600 hertz?

(A) 2.5×10^{-23} kg
(B) 1.2×10^{-22} kg
(C) 3.3×10^{-22} kg
(D) 5.0×10^{-21} kg
(E) 7.5×10^{-21} kg

$$F_{\text{centripetal}} = \frac{mv^2}{R} \qquad F_B = qvB = 2evB$$

$$F_{\text{centripetal}} = F_B \implies m = \frac{2eBR}{v}$$

Tips and Tricks: Derive, don't memorize!

ETS 2001 #62

62. A nonrelativistic particle with a charge twice that of an electron moves through a uniform magnetic field. The field has a strength of $\pi/4$ tesla and is perpendicular to the velocity of the particle. What is the particle's mass if it has a cyclotron frequency of 1,600 hertz?

(A) 2.5×10^{-23} kg
(B) 1.2×10^{-22} kg
(C) 3.3×10^{-22} kg
(D) 5.0×10^{-21} kg
(E) 7.5×10^{-21} kg

$$F_{\text{centripetal}} = \frac{mv^2}{R} \qquad F_B = qvB = 2evB$$

$$F_{\text{centripetal}} = F_B \implies m = \frac{2eBR}{v}$$

$$f = \frac{v}{2\pi R} \implies m = \frac{eB}{\pi f}$$

given numbers mean simple arithmetic

Tips and Tricks: Dimensional Analysis

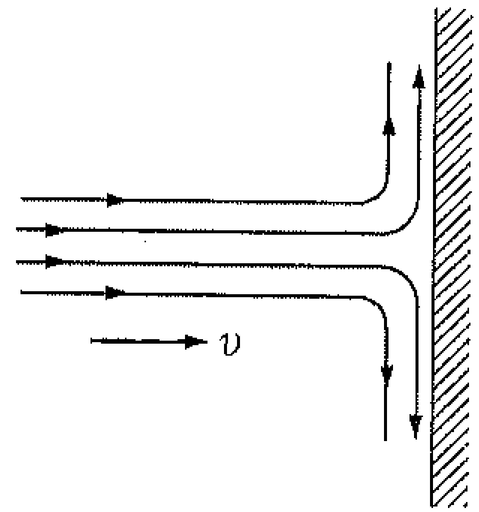
Three fundamental units: mass, length, time

Everything in classical mechanics can be expressed as products of powers of these! (For EM, need charge also)

Sometimes easier to work with composite units (electric and magnetic fields especially, also energy)

Tips and Tricks: Dimensional Analysis

ETS 2001 #57

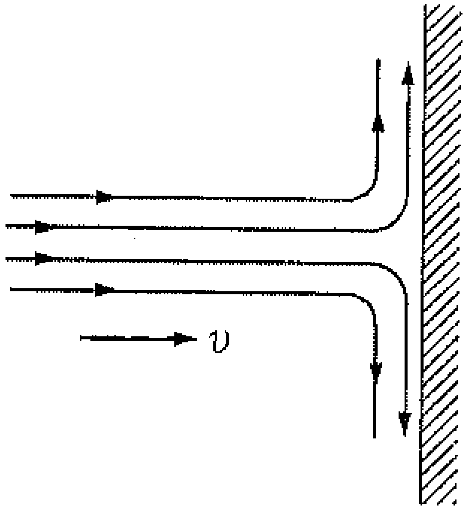


57. A stream of water of density ρ, cross-sectional area A, and speed v strikes a wall that is perpendicular to the direction of the stream, as shown in the figure above. The water then flows sideways across the wall. The force exerted by the stream on the wall is

(A) $\rho v^2 A$
(B) $\rho v A/2$
(C) $\rho g h A$
(D) $v^2 A/\rho$
(E) $v^2 A/2\rho$

Tips and Tricks: Dimensional Analysis

ETS 2001 #57



57. A stream of water of density ρ, cross-sectional area A, and speed v strikes a wall that is perpendicular to the direction of the stream, as shown in the figure above. The water then flows sideways across the wall. The force exerted by the stream on the wall is

(A) $\rho v^2 A$
(B) $\rho v A/2$
(C) $\rho g h A$
(D) $v^2 A/\rho$
(E) $v^2 A/2\rho$

Forget fluid dynamics! Want something with units of force

Tips and Tricks: Dimensional Analysis

ETS 2001 #57

$$[\rho] = [M][L]^{-3}$$

$$[A] = [L]^2$$

$$[v] = [L][T]^{-1}$$

Tips and Tricks: Dimensional Analysis

ETS 2001 #57

$$[\rho] = [M][L]^{-3}$$

$$[A] = [L]^2$$

$$[v] = [L][T]^{-1}$$

$$[F] = [M][L][T]^{-2}$$

$$F = \rho^x A^y v^z$$

Tips and Tricks: Dimensional Analysis

ETS 2001 #57

$$[\rho] = [M][L]^{-3}$$

$$[A] = [L]^2$$

$$[v] = [L][T]^{-1}$$

$$[F] = [M][L][T]^{-2}$$

$$F = \rho^x A^y v^z$$

Algebra or just staring at it: $x = 1, y = 1, v = 2$

Tips and Tricks: Dimensional Analysis

ETS 2001 #57

$$[\rho] = [M][L]^{-3}$$

$$[A] = [L]^2$$

$$[v] = [L][T]^{-1}$$

$$[F] = [M][L][T]^{-2}$$

$$F = \rho^x A^y v^z$$

Algebra or just staring at it: $x = 1, y = 1, v = 2$

(A) $\rho v^2 A$
(B) $\rho v A/2$
(C) $\rho g h A$
(D) $v^2 A/\rho$
(E) $v^2 A/2\rho$

Tips and Tricks: Dimensional Analysis

ETS 2001 #57

$$[\rho] = [M][L]^{-3}$$

$$[A] = [L]^2$$

$$[v] = [L][T]^{-1}$$

$$[F] = [M][L][T]^{-2}$$

$$F = \rho^x A^y v^z$$

Algebra or just staring at it: $x = 1, y = 1, v = 2$

(A) $\rho v^2 A$
(B) $\rho v A/2$
(C) $\rho g h A$
(D) $v^2 A/\rho$
(E) $v^2 A/2\rho$

if eqs. have no solution, need more quantities with units, hence g

Tips and Tricks: Dimensional Analysis

ETS 2001 #65

$$C = 3kN_A\left(\frac{h\nu}{kT}\right)^2 \frac{e^{h\nu/kT}}{(e^{h\nu/kT}-1)^2}$$

65. Einstein's formula for the molar heat capacity C of solids is given above. At high temperatures, C approaches which of the following?

(A) 0

(B) $3kN_A\left(\frac{h\nu}{kT}\right)$

(C) $3kN_A h\nu$

(D) $3kN_A$

(E) $N_A h\nu$

Your turn!

Tips and Tricks: Dimensional Analysis

ETS 2001 #65

$$C = 3kN_A\left(\frac{h\nu}{kT}\right)^2 \frac{e^{h\nu/kT}}{(e^{h\nu/kT} - 1)^2}$$

65. Einstein's formula for the molar heat capacity C of solids is given above. At high temperatures, C approaches which of the following?

(A) 0

(B) $3kN_A\left(\frac{h\nu}{kT}\right)$

(C) $3kN_A h\nu$

(D) $3kN_A$

(E) $N_A h\nu$

$h\nu$ and kT both have units of energy:

Tips and Tricks: Dimensional Analysis

ETS 2001 #65

$$C = 3kN_A\left(\frac{h\nu}{kT}\right)^2 \frac{e^{h\nu/kT}}{(e^{h\nu/kT}-1)^2}$$

65. Einstein's formula for the molar heat capacity C of solids is given above. At high temperatures, C approaches which of the following?

(A) 0

(B) $3kN_A\left(\frac{h\nu}{kT}\right)$

~~(C)~~ $3kN_A h\nu$

(D) $3kN_A$

~~(E)~~ $N_A h\nu$

$h\nu$ and kT both have units of energy:

C has same unit as *k*

Tips and Tricks: Dimensional Analysis

ETS 2001 #65

$$C = 3kN_A\left(\frac{h\nu}{kT}\right)^2 \frac{e^{h\nu/kT}}{(e^{h\nu/kT}-1)^2}$$

65. Einstein's formula for the molar heat capacity C of solids is given above. At high temperatures, C approaches which of the following?

(A) 0

(B) $3kN_A\left(\frac{h\nu}{kT}\right)$

~~(C)~~ $3kN_A h\nu$

(D) $3kN_A$

~~(E)~~ $N_A h\nu$

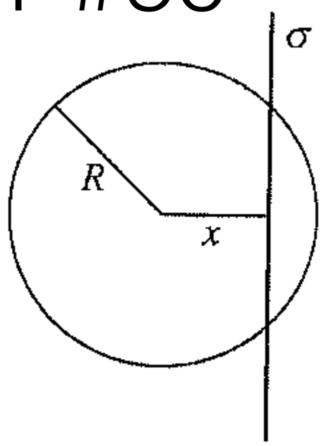
$h\nu$ and kT both have units of energy:

C has same unit as *k*

Taylor expand, or remember equipartition

Tips & Tricks: Limiting Cases

ETS 2001 #60



60. An infinite, uniformly charged sheet with surface-charge density σ cuts through a spherical Gaussian surface of radius R at a distance x from its center, as shown in the figure above. The electric flux Φ through the Gaussian surface is

(A) $\dfrac{\pi R^2 \sigma}{\epsilon_0}$

(B) $\dfrac{2\pi R^2 \sigma}{\epsilon_0}$

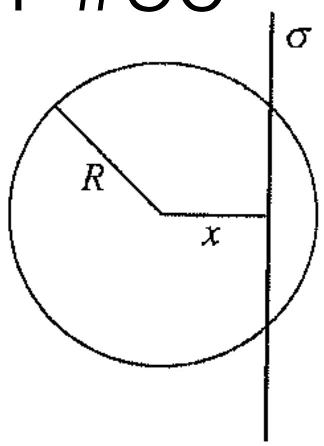
(C) $\dfrac{\pi (R - x)^2 \sigma}{\epsilon_0}$

(D) $\dfrac{\pi (R^2 - x^2)\sigma}{\epsilon_0}$

(E) $\dfrac{2\pi (R^2 - x^2)\sigma}{\epsilon_0}$

Tips & Tricks: Limiting Cases

ETS 2001 #60



60. An infinite, uniformly charged sheet with surface-charge density σ cuts through a spherical Gaussian surface of radius R at a distance x from its center, as shown in the figure above. The electric flux Φ through the Gaussian surface is

(A) $\dfrac{\pi R^2 \sigma}{\epsilon_0}$

(B) $\dfrac{2\pi R^2 \sigma}{\epsilon_0}$

(C) $\dfrac{\pi (R - x)^2 \sigma}{\epsilon_0}$

(D) $\dfrac{\pi (R^2 - x^2) \sigma}{\epsilon_0}$

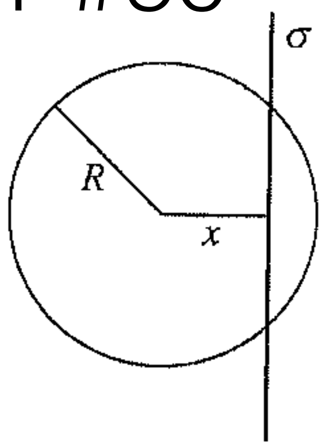
(E) $\dfrac{2\pi (R^2 - x^2) \sigma}{\epsilon_0}$

Recall Gauss's Law:
flux proportional to enclosed charge

Send parameter values to their limits

Tips & Tricks: Limiting Cases

ETS 2001 #60



60. An infinite, uniformly charged sheet with surface-charge density σ cuts through a spherical Gaussian surface of radius R at a distance x from its center, as shown in the figure above. The electric flux Φ through the Gaussian surface is

(A) $\frac{\pi R^2 \sigma}{\epsilon_0}$

(B) $\frac{2\pi R^2 \sigma}{\epsilon_0}$

(C) $\frac{\pi (R-x)^2 \sigma}{\epsilon_0}$

(D) $\frac{\pi (R^2-x^2) \sigma}{\epsilon_0}$

(E) $\frac{2\pi (R^2-x^2) \sigma}{\epsilon_0}$

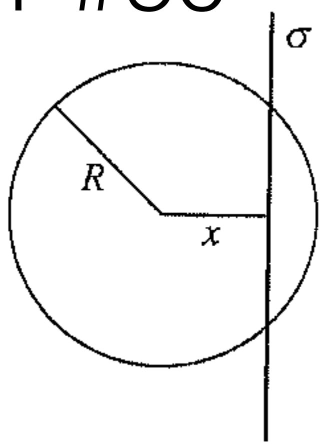
Recall Gauss's Law:
flux proportional to enclosed charge

Send parameter values to their limits

$$x \to R$$

Tips & Tricks: Limiting Cases

ETS 2001 #60



60. An infinite, uniformly charged sheet with surface-charge density σ cuts through a spherical Gaussian surface of radius R at a distance x from its center, as shown in the figure above. The electric flux Φ through the Gaussian surface is

(A) $\frac{\pi R^2 \sigma}{\epsilon_0}$

(B) $\frac{2\pi R^2 \sigma}{\epsilon_0}$

(C) $\frac{\pi (R-x)^2 \sigma}{\epsilon_0}$

(D) $\frac{\pi (R^2-x^2) \sigma}{\epsilon_0}$

(E) $\frac{2\pi (R^2-x^2) \sigma}{\epsilon_0}$

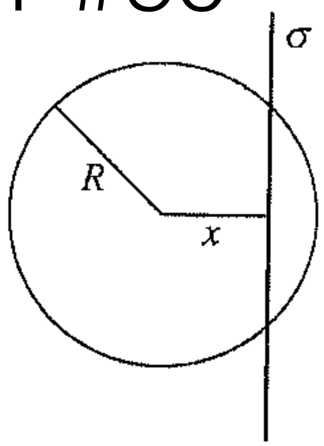
Recall Gauss's Law:
flux proportional to enclosed charge

Send parameter values to their limits

$x \to R$ flux should vanish

Tips & Tricks: Limiting Cases

ETS 2001 #60



60. An infinite, uniformly charged sheet with surface-charge density σ cuts through a spherical Gaussian surface of radius R at a distance x from its center, as shown in the figure above. The electric flux Φ through the Gaussian surface is

(A) $\dfrac{\pi R^2 \sigma}{\epsilon_0}$

(B) $\dfrac{2\pi R^2 \sigma}{\epsilon_0}$

(C) $\dfrac{\pi (R-x)^2 \sigma}{\epsilon_0}$

(D) $\dfrac{\pi (R^2-x^2) \sigma}{\epsilon_0}$

(E) $\dfrac{2\pi (R^2-x^2) \sigma}{\epsilon_0}$

Recall Gauss's Law:
flux proportional to enclosed charge

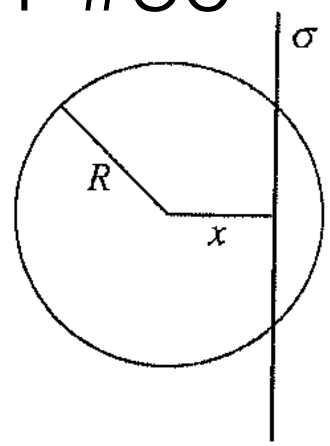
Send parameter values to their limits

$x \to R$ flux should vanish

$x \to -R$

Tips & Tricks: Limiting Cases

ETS 2001 #60



60. An infinite, uniformly charged sheet with surface-charge density σ cuts through a spherical Gaussian surface of radius R at a distance x from its center, as shown in the figure above. The electric flux Φ through the Gaussian surface is

~~(A)~~ $\dfrac{\pi R^2 \sigma}{\epsilon_0}$

~~(B)~~ $\dfrac{2\pi R^2 \sigma}{\epsilon_0}$

~~(C)~~ $\dfrac{\pi (R-x)^2 \sigma}{\epsilon_0}$

(D) $\dfrac{\pi (R^2 - x^2) \sigma}{\epsilon_0}$

(E) $\dfrac{2\pi (R^2 - x^2) \sigma}{\epsilon_0}$

Recall Gauss's Law:
flux proportional to enclosed charge

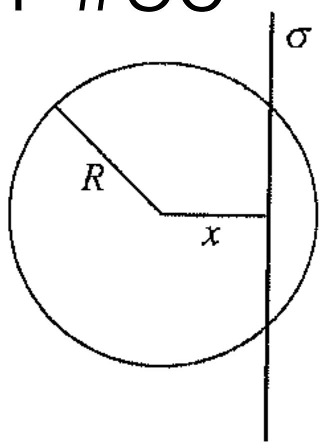
Send parameter values to their limits

$x \to R$ flux should vanish

$x \to -R$ flux should also vanish!

Tips & Tricks: Limiting Cases

ETS 2001 #60



60. An infinite, uniformly charged sheet with surface-charge density σ cuts through a spherical Gaussian surface of radius R at a distance x from its center, as shown in the figure above. The electric flux Φ through the Gaussian surface is

~~(A)~~ $\frac{\pi R^2 \sigma}{\epsilon_0}$

~~(B)~~ $\frac{2\pi R^2 \sigma}{\epsilon_0}$

~~(C)~~ $\frac{\pi (R-x)^2 \sigma}{\epsilon_0}$

(D) $\frac{\pi (R^2 - x^2) \sigma}{\epsilon_0}$

(E) $\frac{2\pi (R^2 - x^2) \sigma}{\epsilon_0}$

Recall Gauss's Law:
flux proportional to enclosed charge

Send parameter values to their limits

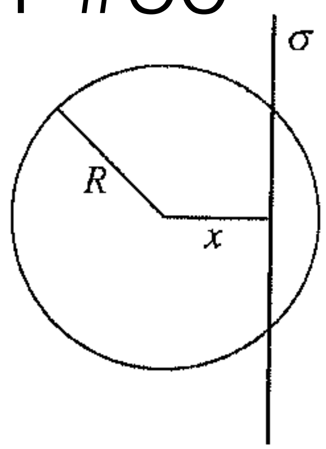
$x \to R$ flux should vanish

$x \to -R$ flux should also vanish!

$x \to 0$

Tips & Tricks: Limiting Cases

ETS 2001 #60



60. An infinite, uniformly charged sheet with surface-charge density σ cuts through a spherical Gaussian surface of radius R at a distance x from its center, as shown in the figure above. The electric flux Φ through the Gaussian surface is

~~(A)~~ $\frac{\pi R^2 \sigma}{\epsilon_0}$

~~(B)~~ $\frac{2\pi R^2 \sigma}{\epsilon_0}$

~~(C)~~ $\frac{\pi (R-x)^2 \sigma}{\epsilon_0}$

(D) $\frac{\pi (R^2 - x^2) \sigma}{\epsilon_0}$

~~(E)~~ $\frac{2\pi (R^2 - x^2) \sigma}{\epsilon_0}$

Recall Gauss's Law:
flux proportional to enclosed charge

Send parameter values to their limits

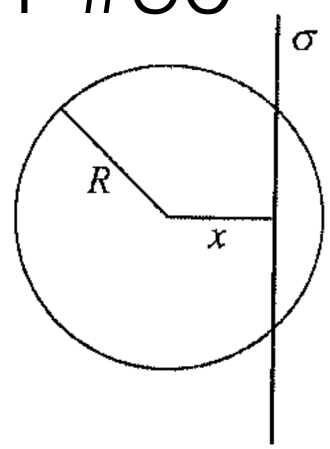
$x \to R$ flux should vanish

$x \to -R$ flux should also vanish!

$x \to 0$ circle, expect πR^2

Tips & Tricks: Limiting Cases

ETS 2001 #60



60. An infinite, uniformly charged sheet with surface-charge density σ cuts through a spherical Gaussian surface of radius R at a distance x from its center, as shown in the figure above. The electric flux Φ through the Gaussian surface is

(A) $\frac{\pi R^2 \sigma}{\epsilon_0}$

(B) $\frac{2\pi R^2 \sigma}{\epsilon_0}$

(C) $\frac{\pi (R-x)^2 \sigma}{\epsilon_0}$

(D) $\frac{\pi (R^2-x^2) \sigma}{\epsilon_0}$

(E) $\frac{2\pi (R^2-x^2) \sigma}{\epsilon_0}$

Recall Gauss's Law:
flux proportional to enclosed charge

Send parameter values to their limits

$x \to R$ flux should vanish

$x \to -R$ flux should also vanish!

$x \to 0$ circle, expect πR^2

Get choice D, no complicated geometry!

Tips & Tricks: Limiting Cases

ETS 2008 #59

59. A simple pendulum of length l is suspended from the ceiling of an elevator that is accelerating upward with constant acceleration a. For small oscillations, the period, T, of the pendulum is

(A) $T = 2\pi\sqrt{\frac{l}{g}}$

(B) $T = 2\pi\sqrt{\frac{l}{g-a}}$

(C) $T = 2\pi\sqrt{\frac{l}{g+a}}$

(D) $T = 2\pi\sqrt{\frac{l}{g}\frac{a}{(g+a)}}$

(E) $T = 2\pi\sqrt{\frac{l}{g}\frac{(g+a)}{a}}$

Your turn!

Tips & Tricks: Limiting Cases

ETS 2008 #59

59. A simple pendulum of length l is suspended from the ceiling of an elevator that is accelerating upward with constant acceleration a. For small oscillations, the period, T, of the pendulum is

(A) $T = 2\pi\sqrt{\frac{l}{g}}$

(B) $T = 2\pi\sqrt{\frac{l}{g - a}}$

(C) $T = 2\pi\sqrt{\frac{l}{g + a}}$

(D) $T = 2\pi\sqrt{\frac{l}{g}\frac{a}{(g + a)}}$

(E) $T = 2\pi\sqrt{\frac{l}{g}\frac{(g + a)}{a}}$

$$a \rightarrow 0$$

Tips & Tricks: Limiting Cases

ETS 2008 #59

59. A simple pendulum of length l is suspended from the ceiling of an elevator that is accelerating upward with constant acceleration a. For small oscillations, the period, T, of the pendulum is

(A) $T = 2\pi\sqrt{\frac{l}{g}}$

(B) $T = 2\pi\sqrt{\frac{l}{g - a}}$

(C) $T = 2\pi\sqrt{\frac{l}{g + a}}$

~~(D)~~ $T = 2\pi\sqrt{\frac{l}{g}\frac{a}{(g + a)}}$

~~(E)~~ $T = 2\pi\sqrt{\frac{l}{g}\frac{(g + a)}{a}}$

$a \to 0$ nothing should blow up or vanish

Tips & Tricks: Limiting Cases

ETS 2008 #59

59. A simple pendulum of length l is suspended from the ceiling of an elevator that is accelerating upward with constant acceleration a. For small oscillations, the period, T, of the pendulum is

(A) $T = 2\pi\sqrt{\frac{l}{g}}$

(B) $T = 2\pi\sqrt{\frac{l}{g - a}}$

(C) $T = 2\pi\sqrt{\frac{l}{g + a}}$

~~(D)~~ $T = 2\pi\sqrt{\frac{l}{g}\frac{a}{(g + a)}}$

~~(E)~~ $T = 2\pi\sqrt{\frac{l}{g}\frac{(g + a)}{a}}$

$a \to 0$ nothing should blow up or vanish

$a = -g$

Tips & Tricks: Limiting Cases

ETS 2008 #59

59. A simple pendulum of length l is suspended from the ceiling of an elevator that is accelerating upward with constant acceleration a. For small oscillations, the period, T, of the pendulum is

(A) $T = 2\pi\sqrt{\frac{l}{g}}$

(B) $T = 2\pi\sqrt{\frac{l}{g-a}}$

(C) $T = 2\pi\sqrt{\frac{l}{g+a}}$

~~(D)~~ $T = 2\pi\sqrt{\frac{l}{g}\frac{a}{(g+a)}}$

~~(E)~~ $T = 2\pi\sqrt{\frac{l}{g}\frac{(g+a)}{a}}$

$a \to 0$ nothing should blow up or vanish

$a = -g$ Equivalence Principle: pendulum is "weightless"

Tips & Tricks: Numbers and Estimation

The only 5 numbers you need to memorize for the GRE:

- 13.6 eV - hydrogen atom binding energy
- 511 keV - mass of the electron (units of c^2)
- 1.22 - coefficient in Rayleigh criterion
- 2.7 K - temperature of cosmic microwave background
- 3×10^{-3} m•K - Wien's law coefficient

Everything else should be given on formula sheet
or in the exam questions themselves

Tips & Tricks: Numbers and Estimation

11. The ratio of the nuclear radius to the atomic radius of an element near the middle of the periodic table is most nearly

(A) 10^{-2} (B) 10^{-5} (C) 10^{-8} (D) 10^{-11} (E) 10^{-14}

(from ETS supplemental material)

Tips & Tricks: Numbers and Estimation

11. The ratio of the nuclear radius to the atomic radius of an element near the middle of the periodic table is most nearly

(A) 10^{-2} (B) 10^{-5} (C) 10^{-8} (D) 10^{-11} (E) 10^{-14}

(from ETS supplemental material)

convert energy to length with $\hbar c \approx 200 \text{ MeV} \cdot \text{fm} = 200 \text{ eV} \cdot \text{nm}$

Tips & Tricks: Numbers and Estimation

11. The ratio of the nuclear radius to the atomic radius of an element near the middle of the periodic table is most nearly

(A) 10^{-2} (B) 10^{-5} (C) 10^{-8} (D) 10^{-11} (E) 10^{-14}

(from ETS supplemental material)

convert energy to length with $\hbar c \approx 200\ \mathrm{MeV} \cdot \mathrm{fm} = 200\ \mathrm{eV} \cdot \mathrm{nm}$

Nuclear scale?

Atomic scale?

Tips & Tricks: Numbers and Estimation

11. The ratio of the nuclear radius to the atomic radius of an element near the middle of the periodic table is most nearly

(A) 10^{-2} (B) 10^{-5} (C) 10^{-8} (D) 10^{-11} (E) 10^{-14}

(from ETS supplemental material)

convert energy to length with $\hbar c \approx 200\ \mathrm{MeV} \cdot \mathrm{fm} = 200\ \mathrm{eV} \cdot \mathrm{nm}$

Nuclear scale?

- proton has mass of about 1 GeV
- "size" close to femtometer (10^{-15} m)
- Z = 50, probably 10-100 fm

Atomic scale?

Tips & Tricks: Numbers and Estimation

11. The ratio of the nuclear radius to the atomic radius of an element near the middle of the periodic table is most nearly

(A) 10^{-2} (B) 10^{-5} (C) 10^{-8} (D) 10^{-11} (E) 10^{-14}

(from ETS supplemental material)

convert energy to length with $\hbar c \approx 200\ \mathrm{MeV \cdot fm} = 200\ \mathrm{eV \cdot nm}$

Nuclear scale?

- proton has mass of about 1 GeV
- "size" close to femtometer (10^{-15} m)
- Z = 50, probably 10-100 fm

Atomic scale?

- 13.6 eV binding energy for hydrogen
- Bohr radius is 10^{-10} m
- maybe 10^{-9} m for Z = 50

Tips & Tricks: Numbers and Estimation

11. The ratio of the nuclear radius to the atomic radius of an element near the middle of the periodic table is most nearly

(A) 10^{-2} (B) 10^{-5} (C) 10^{-8} (D) 10^{-11} (E) 10^{-14}

(from ETS supplemental material)

convert energy to length with $\hbar c \approx 200\ \mathrm{MeV} \cdot \mathrm{fm} = 200\ \mathrm{eV} \cdot \mathrm{nm}$

Nuclear scale?

- proton has mass of about 1 GeV
- "size" close to femtometer (10^{-15} m)
- Z = 50, probably 10-100 fm

Atomic scale?

- 13.6 eV binding energy for hydrogen
- Bohr radius is 10^{-10} m
- maybe 10^{-9} m for Z = 50

Ratio is closest to 10^{-5}

Tips & Tricks: Numbers and Estimation

ETS 2001 #13

13. Two stars are separated by an angle of 3×10^{-5} radians. What is the diameter of the smallest telescope that can resolve the two stars using visible light ($\lambda \cong 600$ nanometers) ? (Ignore any effects due to Earth's atmosphere.)

(A) 1 mm
(B) 2.5 cm
(C) 10 cm
(D) 2.5 m
(E) 10 m

Your turn!

Tips & Tricks: Numbers and Estimation

ETS 2001 #13

13. Two stars are separated by an angle of 3×10^{-5} radians. What is the diameter of the smallest telescope that can resolve the two stars using visible light ($\lambda \cong 600$ nanometers) ? (Ignore any effects due to Earth's atmosphere.)

(A) 1 mm
(B) 2.5 cm
(C) 10 cm
(D) 2.5 m
(E) 10 m

$$D \sin\theta = 1.22\lambda$$

Small angle approx: $\sin\theta \approx \theta$

Tips & Tricks: Numbers and Estimation

ETS 2001 #13

13. Two stars are separated by an angle of 3×10^{-5} radians. What is the diameter of the smallest telescope that can resolve the two stars using visible light ($\lambda \cong 600$ nanometers)? (Ignore any effects due to Earth's atmosphere.)

(A) 1 mm
(B) 2.5 cm
(C) 10 cm
(D) 2.5 m
(E) 10 m

$$D \sin\theta = 1.22\lambda$$

Small angle approx: $\sin\theta \approx \theta$

$$D \approx \frac{1.22\lambda}{\theta} \approx 2.5 \text{ cm}$$

Tips & Tricks - Answer Types

Easier:

57. A stream of water of density ρ, cross-sectional area A, and speed v strikes a wall that is perpendicular to the direction of the stream, as shown in the figure above. The water then flows sideways across the wall. The force exerted by the stream on the wall is

(A) $\rho v^2 A$
(B) $\rho v A/2$
(C) $\rho g h A$
(D) $v^2 A/\rho$
(E) $v^2 A/2\rho$

Different units

13. Two stars are separated by an angle of 3×10^{-5} radians. What is the diameter of the smallest telescope that can resolve the two stars using visible light ($\lambda \cong 600$ nanometers)? (Ignore any effects due to Earth's atmosphere.)

(A) 1 mm
(B) 2.5 cm
(C) 10 cm
(D) 2.5 m
(E) 10 m

Order of magnitude

35. If the absolute temperature of a blackbody is increased by a factor of 3, the energy radiated per second per unit area does which of the following?

(A) Decreases by a factor of 81.
(B) Decreases by a factor of 9.
(C) Increases by a factor of 9.
(D) Increases by a factor of 27.
(E) Increases by a factor of 81.

"Which power of 3?"

46. A free particle with initial kinetic energy E and de Broglie wavelength λ enters a region in which it has potential energy V. What is the particle's new de Broglie wavelength?

(A) $\lambda(1 + E/V)$
(B) $\lambda(1 - V/E)$
(C) $\lambda(1 - E/V)^{-1}$
(D) $\lambda(1 + V/E)^{1/2}$
(E) $\lambda(1 - V/E)^{-1/2}$

Different limiting cases

Tips & Tricks - Answer Types

Harder:

32. If the total energy of a particle of mass m is equal to twice its rest energy, then the magnitude of the particle's relativistic momentum is

(A) $mc/2$
(B) $mc/\sqrt{2}$
(C) mc
(D) $\sqrt{3}\,mc$
(E) $2mc$

Same units, different numbers

33. If a charged pion that decays in 10^{-8} second in its own rest frame is to travel 30 meters in the laboratory before decaying, the pion's speed must be most nearly

(A) 0.43×10^8 m/s
(B) 2.84×10^8 m/s
(C) 2.90×10^8 m/s
(D) 2.98×10^8 m/s
(E) 3.00×10^8 m/s

Random numbers

Work problem slowly,
don't get distracted by answer choices!

Tips & Tricks - Fermi problems

"How many piano tuners are there in New York City?"
"How many photons hit the Earth every day?"

Solving problems like these require quick-and-dirty estimates paired with good physical intuition - good practice for the GRE!

See "Conquering" Ch. 9 sec. 6 for a worked example, or V. Weisskopf, "Modern Physics from an Elementary Point of View"

http://cds.cern.ch/record/274976/files/CERN-70-08.pdf?version=1

(or XKCD's "What If" series)

Wrapping up

Please feel free to email with further questions!

ykahn@princeton.edu

Best of luck studying!