

# PHYSICS

## 1. PHYSICS

### Toss Up: Multiple Choice

If the wave function  $\psi$  is spherically symmetric then the radial probability density is given by: If the wave function  $\psi$  is spherically symmetric then the radial probability density is given by:

- W)  $4\pi r^2 \psi$
- X)  $|\psi|^2$
- Y)  $4\pi r^2 |\psi|^2$
- Z)  $4\pi |\psi|^2$

Toss Up Answer: Y

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### Bonus: Short Answer

Maxwell's equations are to electric and magnetic fields as [ ] equation is to the wave function for a particle.

Bonus Answer: Schrodinger's

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## 2. PHYSICS

### Toss Up: Multiple Choice

A non-relativistic free electron has kinetic energy K. If its wavelength doubles, what is its kinetic energy in terms of K?

- W) 4K
- X) K/4
- Y) K
- Z) K/2

Toss Up Answer: X

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### Bonus: Short Answer

A molecule with a magnetic moment of  $83 \text{ N}\cdot\text{m/T}$  (read as Newton-meters per Tesla) experiences what amount of torque in  $\text{N}\cdot\text{m}$  (read as Newton-meter) when subjected to an external magnetic force of 120 teslas?

Bonus Answer:  $9960 \text{ N}\cdot\text{m}$

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## 3. PHYSICS

### Toss Up: Short Answer

The Laplacian of an electric potential field is equal to the negative free charge density over this quantity. This quantity is equal to the negative time derivative of the magnetic flux, and in an inductor, it is equivalent to the inductance multiplied by the negative time derivative of the current. It is classically defined as Coulomb's constant multiplied by the sum of charge over distance, and also as the line integral of the electric field "dot dl." When it is multiplied by current, it gives power dissipated by a resistor. Kirchoff's Loop Rule states that the sum of this value around a loop in a circuit is zero. Name this quantity this is equal to the current times resistance by Ohm's Law.

Bonus Answer: Voltage (accept electric potential)

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### Bonus: Multiple Choice

A certain capacitor, in series with a  $720\text{-}\Omega$  resistor, is being charged. At the end of 10 ms (milliseconds) its charge is half the final value. The capacitance is about:

- W)  $9.6 \mu\text{F}$
- X)  $14 \mu\text{F}$
- Y)  $20 \mu\text{F}$
- Z)  $7.2\text{F}$

Bonus Answer: Y

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## 4. PHYSICS

### Toss Up: Multiple Choice

In the capacitor discharge formula  $q = q_0 e^{-t/(RC)}$  (read as  $q$  naught times  $e$  raised to the power of negative  $t$  over quantity  $R$  times  $C$ ) the term  $RC$  is more commonly referred to as:

- W) The time limit
- X) The time of charge
- Y) The time constant
- Z) It does not have a specific name

**Toss Up Answer: Z**

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### Bonus: Short Answer

Resistor 1 has twice the resistance of resistor 2. They are connected in parallel to a battery. The ratio of the thermal energy generation rate in 1 to that in 2 is:

**Bonus Answer: 1:2**

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## 5. PHYSICS

### Toss Up: Short Answer

What is the equivalent capacitance in Farads of two capacitors connected in series, one with a capacitance of 4 microFarads and the other with a capacitance of 2 microFarads?

**Bonus Answer: 4/3 microFarads**

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### Bonus: Short Answer

Give your answer in scientific notation, in Farads, rounded to the nearest tenth. What is the approximate capacitance between two parallel plates of surface area 10cm squared, separated by a distance of 1 meter?

**Bonus Answer:  $8.9 \times 10^{-14}$  Farads**

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## 6. PHYSICS

### Toss Up: Multiple Choice

Which of the following is NOT true about magnetism?

- W) Electric field lines go from the North pole to the South pole
- X) There are instances where electric field lines cross each other
- Y) Cutting a magnet in half will not create two magnetic monopoles
- Z) They are all true

**Toss Up Answer: X**

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### Bonus: Short Answer

By name or number, list all of the following elements that are ferromagnetic: Cobalt, Manganese, Cobalt, Cadmium, Silver

**Bonus Answer: Cobalt. Accept: Co, 1**

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## 7. PHYSICS

### Toss Up: Short Answer

When charging or discharging a capacitor, what the quantity  $RC$  (read as resistance times capacitance) known as?

**Bonus Answer: Time constant**

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### Bonus: Multiple Choice

At point 'A' on a circuit the wire is grounded. At point 'B' on the same circuit there is a emf of 30 volts. If there are two identical resistors with resistance of 10 ohms in parallel, between point 'A' and point 'B', what is the current in ampere flowing through either resistor?

- W) 15

- X) 3
- Y) 9
- Z) 6

**Bonus Answer: X**

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## 8. PHYSICS

**Toss Up: Multiple Choice**

A magnetic field CANNOT:

- W) Exert a force on a charged particle
- X) Change the trajectory of a charged particle
- Y) Change the kinetic energy of a charged particle
- Z) Do no work on a charged particle

**Toss Up Answer: Y**

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**Bonus: Multiple Choice**

A magnet and a conducting loop are placed next to each other at rest on a horizontal surface. If the magnet with the north pole facing left is put through the loop and is moved left in which direction will the induced current within the loop move with reference to the magnet?

- W) Into the magnet
- X) Counter-clockwise
- Y) Clockwise
- Z) There is no current.

**Bonus Answer: X**

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## 9. PHYSICS

**Toss Up: Short Answer**

Which principle of quantum mechanics allows for the quantum state of any particle to be expressed as a linear combination of distinct quantum states?

**Bonus Answer: Superposition principle**

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**Bonus: Short Answer**

A free electron has a momentum of  $5.0 \times 10^{-24}$  kg · m/s (read as 5.0 times 10 to the negative 24 kilogram times meter per second). The wavelength of its wave function in meters is:

**Bonus Answer:  $\sim 1.3 \times 10^{-10}$  meters (explanation: deBroglie wavelength)**

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## 10. PHYSICS

**Toss Up: Multiple Choice**

In a simple series circuit, which of these is equal among all resistors?

- W) Potential difference
- X) Resistance
- Y) Current
- Z) Capacitance

**Toss Up Answer: Y**

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**Bonus: Multiple Choice**

A circuit is made with a battery and four resistors connected in series. Two resistors changed to be in parallel in the

circuit. What is the change in the power dissipated by the original two resistors?

- W) The power increases
- X) The power decreases
- Y) The power stays the same
- Z) No power is being generated by any resistor

**Bonus Answer: W**

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## 11. PHYSICS

**Toss Up: Short Answer**

How many bosons are in a regular hydrogen atom?

**Bonus Answer: 1 (it's the electron)**

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**Bonus: Short Answer**

Two forces have magnitudes of 15 newtons and 5 newtons. Using interval notation, what is the range of the possible magnitudes of their sum?

**Bonus Answer: [10, 20], accept: between 10 and 20 Newtons inclusive**

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## 12. PHYSICS

**Toss Up: Short Answer**

What is the name for the effect that explains the small attractive force that acts between two close parallel uncharged conducting plates in a vacuum?

**Bonus Answer: The Casimir Effect**

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**Bonus: Multiple Choice**

According to Beer's law:

- W) the energy of a photon of light is inversely proportional to its wavelength
- X) the concentration of a species that absorbs light can be measured by the amount of light absorbed
- Y) the energy of characteristic X-rays increases with increasing atomic number of the emitting element
- Z) excitation of the electrons in a molecule takes place on a shorter time scale than motion of the nuclei

**Bonus Answer: X**

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## 13. PHYSICS

**Toss Up: Short Answer**

The Curie temperature is the temperature at which ferromagnets become paramagnets. What is the name for the point at which antiferromagnets become paramagnets?

**Bonus Answer: The Neel temperature**

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**Bonus: Multiple Choice**

A hall probe measures which of the following:

- W) Capacitance
- X) Viscosity
- Y) Magnetic Field
- Z) Electric Field

**Bonus Answer: Y**

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## 14. PHYSICS

**Toss Up: Multiple Choice**

The equation of continuity for fluid flow can be derived from the conservation of:

- W) Energy
- X) Mass
- Y) Angular momentum
- Z) Volume

**Toss Up Answer: X**

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**Bonus: Multiple Choice**

A coil has a resistance of  $60\Omega$  and an impedance of  $100\Omega$ . Its reactance, in ohms, is:

- W) 40
- X) 60
- Y) 80
- Z) 117

**Bonus Answer: Y**

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## 15. PHYSICS

**Toss Up: Multiple Choice**

Monochromatic light is normally incident on a diffraction grating that is 1cm wide and has 10,000 slits. The first order line is deviated at a  $30^\circ$  angle. What is the wavelength, in nm, of the incident light?

- W) 300
- X) 500
- Y) 877
- Z) 1000

**Toss Up Answer: X**

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**Bonus: Multiple Choice**

A spectral line of a certain star is observed to be "red shifted" from a wavelength of 500nm to a wavelength of 1500nm. Interpreting this as a Doppler effect, the speed of recession of this star is:

- W) .33c
- X) .5c
- Y) .71c
- Z) .8c

**Bonus Answer: Z**

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## 16. PHYSICS

**Toss Up: Multiple Choice**

An acceptor replacement atom in silicon might have how many electrons in its outer shell?

- W) 3
- X) 4
- Y) 5
- Z) 6

**Toss Up Answer: W**

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**Bonus: Multiple Choice**

When a forward bias is applied to a p-n junction the concentration of electrons on the p side:

- W) increases slightly
- X) decreases slightly
- Y) increases dramatically
- Z) decreases dramatically

**Bonus Answer: Y**

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## 17. PHYSICS

### Toss Up: Multiple Choice

The binding energy of a nucleus is the energy that must be supplied to:

- W) Remove a nucleon
- X) Remove an alpha particle
- Y) Remove a beta particle
- Z) Separate the nucleus into its constituent nucleons

**Toss Up Answer: Z**

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### Bonus: Multiple Choice

A radium atom,  $^{226}\text{Ra}$  emits an alpha particle. The number of protons in the resulting atom is

- W) 84
- X) 85
- Y) 86
- Z) 88

**Bonus Answer: W**

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## 18. PHYSICS

### Toss Up: Multiple Choice

Any change in the magnetic environment of a coil of wire will cause a voltage (emf) to be "induced" in the coil. Which law summarizes the ways in which voltage can be generated using this method?

- W) Ohm's Law
- X) Faraday's Law
- Y) Pascal's Law
- Z) Coulomb's Law

**Toss Up Answer: X**

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### Bonus: Short Answer

A magnet is brought close to a flat square coil of 50 loops. The coil is .2 meters on each side, and the magnetic field passing through the coil increased uniformly from 3 Tesla to 8 Tesla in 4 seconds. While that change in magnetic field takes place, using correct signs, what is the induced emf in the coil?

**Bonus Answer: -2.5 Volts**

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## 19. PHYSICS

### Toss Up: Short Answer

What is the metric unit for mass?

**Bonus Answer: Kilogram (kg)**

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### Bonus: Short Answer

What is the SI unit of force?

**Bonus Answer: Newton**

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## 20. PHYSICS

### Toss Up: Short Answer

What is the S.I. unit for Inductance?

**Bonus Answer: Henry**

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### Bonus: Multiple Choice

Which law states that for any closed loop path, the sum of the length elements times the magnetic field in the direction of the length element is equal to the permeability times the electric current enclosed in the loop?

W) Faraday's Law of Induction

X) Kirchhoff's Law

Y) Coulomb's Law

Z) Ampere's Law

**Bonus Answer: Z**

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## 21. PHYSICS

### Toss Up: Short Answer

What is the equivalent capacitance of three Capacitors, each of 9 micro Farad Capacitance, placed in parallel?

**Bonus Answer: 27 micro Farads**

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### Bonus: Short Answer

Determine the amount of charge stored on either plate of a capacitor of 4 micro Farads when connected across a 12 Volt batter.

**Bonus Answer: 48 micro Coulombs,  $4.8 \times 10^{-5}$  Coulombs**

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## 22. PHYSICS

### Toss Up: Short Answer

What is the unit of a Poynting vector?

**Bonus Answer: Watt/meter<sup>2</sup> (accept equivalent variations)**

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### Bonus: Short Answer

What's the order of magnitude of a Poynting vector of an EM wave, where the amplitude of the electric field is 300 N/C (newton per coulomb) and the amplitude of the magnetic field is 400 tesla?

**Bonus Answer: 11**

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## 23. PHYSICS

### Toss Up: Short Answer

What is the total voltage of a circuit with a total current of 10 Amperes running through four resistors placed in parallel, each with a resistance of 4 Ohms?

**Bonus Answer: 10 Volts**

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### Bonus: Short Answer

What does the abbreviation MOSFET stand for?

**Bonus Answer: Metal-Oxide-Semiconductor Field-Effect Transistor**

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## 24. PHYSICS

### Toss Up: Short Answer

What is the magnitude of the magnetic force caused by an electric current of 10 Amperes flowing perpendicular to a magnetic field of 10 Teslas through a length of 10 meters?

**Bonus Answer: 1000 Newtons**

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**Bonus: Multiple Choice**

Two point charges are placed on the x-axis. The first has a charge of -3 Coulombs and is placed at  $x=0$ . The second is placed 3 meters to the right of the first and has a charge of 3 Coulombs. What is the dipole moment of these charges?

- W) 9 Coulomb-Meters in the direction of the positive x-axis
- X) 1 Coulomb-Meters in the direction of the positive x-axis
- Y) 9 Coulomb-Meters in the direction of the negative x-axis
- Z) 1 Coulomb-Meters in the direction of the negative x-axis

**Bonus Answer: W**

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**25. PHYSICS**

**Toss Up: Short Answer**

What is a famous impossible result of the classical modeling of blackbody intensity as a function of frequency?

**Bonus Answer: "Ultraviolet Catastrophe"**

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**Bonus: Multiple Choice**

What is the classical law that attempts to map blackbody intensity as a function of frequency and leads to "ultraviolet catastrophe"?

- W) Henderson-Hasselbalch's Law
- X) Rayleigh-Jeans Law
- Y) Plank's Law
- Z) Kirchhoff Law

**Bonus Answer: X**

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**26. PHYSICS**

**Toss Up: Short Answer**

Which law says that the total electric flux of a closed surface is equal to the charge enclosed divided by the permittivity?

**Bonus Answer: Gauss's Law**

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**Bonus: Multiple Choice**

What is the electric permittivity of free space?

- W)  $2.27 \times 10^{(-12)}$  Farads / meters
- X)  $8.85 \times 10^{(-12)}$  Farads / meters
- Y)  $8.99 \times 10^{(9)}$  Farads / meters
- Z)  $6.67 \times 10^{(-11)}$  Farads / meters

**Bonus Answer: X**

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**27. PHYSICS**

**Toss Up: Multiple Choice**

Why do the bubbles from a freshly opened bottle of champagne grow as they rise to the surface?

- W) Fluid pressure falls as the bubble rises in the glass.
- X) The bubble continues to accumulate dissolved gas molecules as it moves through the champagne.
- Y) The bubble does expansive work on the champagne as it loses potential energy.
- Z) Friction with the champagne heats the gas inside the bubble.



**Toss Up Answer: X**

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**Bonus: Multiple Choice**

The bubbles in a glass of champagne form a steady stream and leave the surface of the glass in regular time intervals. Why is this?

- W) It takes a constant amount of time for gas from the air to make it to the growing bubble.
- X) The bubbles occur due to vibrations in the room that have a constant frequency.
- Y) The bubbles rise when the buoyant force exceeds the adhesive force.
- Z) The bubbles form due to pressure waves in the champagne that have a constant wavelength.

**Bonus Answer: Y**

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**28. PHYSICS**

**Toss Up: Multiple Choice**

For what major contribution was Albert Einstein awarded the nobel prize in 1921?

- W) Einstein Field Equations
- X) General Theory of Relativity
- Y) Special Theory of Relativity
- Z) Photoelectric Effect

**Toss Up Answer: Z**

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**Bonus: Multiple Choice**

Which year in Albert Einstein's life is now known as his "annus mirabilis"?

- W) 1905
- X) 1921
- Y) 1915
- Z) 1928

**Bonus Answer: W**

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**29. PHYSICS**

**Toss Up: Multiple Choice**

Which law of thermodynamics states that if two thermodynamic systems are each in thermal equilibrium with a third, then they are in thermal equilibrium with each other?

- W) Fourth
- X) Third
- Y) Second
- Z) Zeroth

**Toss Up Answer: Z**

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**Bonus: Multiple Choice**

What factor is the energy density in radiation of a region of space changed by if the absolute temperature is increased by a factor of 2?

- W) Times 4
- X) Times 1/4
- Y) Times 2

Z) Times 16

**Bonus Answer: Z**

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### 30. PHYSICS

**Toss Up: Short Answer**

What is the first derivative of velocity?

**Bonus Answer: Acceleration**

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**Bonus: Short Answer**

If you are on an asteroid 100 km in diameter and it is rotating at 200 meters per second, what is your angular acceleration?

**Bonus Answer: 0.4 meters per second**

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### 31. PHYSICS

**Toss Up: Short Answer**

Given two frequencies of 410 Hertz and 412 Hertz, what is the period of the beats produced?

**Bonus Answer: .5 seconds**

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**Bonus: Short Answer**

A car is driving away at 50 meters/seconds from an observer at rest. The car is emitting a frequency at 80 Hz. What is the apparent frequency for the observer, given that the speed of sound is 350 meters/seconds? Give your answer to the nearest integer.

**Bonus Answer: 70 Hertz**

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### 32. PHYSICS

**Toss Up: Multiple Choice**

What is true about the capacitance of two parallel plates?

- W) it is proportional to the square of the Area of the plates
- X) it is proportional to the inverse of the Area of the plates
- Y) it is proportional to the inverse of the plate separation
- Z) it is proportional to the plate separation

**Toss Up Answer: Y**

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**Bonus: Multiple Choice**

A 200 farad capacitor is used in a circuit. The voltage difference between the plates of the capacitor is 10 volts. What is the magnitude of the charge on each of the capacitor's plates?

- W) 100 Coulombs
- X) 2000 Coulombs
- Y) 10 Coulombs
- Z) 200 Coulombs

**Bonus Answer: X**

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### 33. PHYSICS

**Toss Up: Short Answer**

What color is a mirror?

**Bonus Answer: green**

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**Bonus: Short Answer**

Using  $g = 10 \text{ m/s}^2$ , given the weight of an object is 2700 Newtons, what is the mass of the object on the Moon, if its gravitational force is  $1/6$  as strong as that on Earth? Round your answer to the first decimal place.

**Bonus Answer: 270 kg**

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**34. PHYSICS****Toss Up: Short Answer**

Which of the following units are a measure of magnetic field strength?

- 1 - Gauss
- 2 - Tesla
- 3 - Weber
- 4 - Henry

**Bonus Answer: 1,2 (Gauss, Tesla)**

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**Bonus: Multiple Choice**

If the axle of a wheel is moving at a velocity of  $v$ , what is the instantaneous velocity of the top of the wheel?

- W)  $-2v$
- X) 0
- Y)  $v$
- Z)  $2v$

**Bonus Answer: Z**

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**35. PHYSICS****Toss Up: Multiple Choice**

Which of the following explains what happens when a negatively charged rod is held to the metal conductor of a leaf electroscope?

- W) The leaves close because electrons flow from the rod to the electroscope, resulting in a net negative charge in the electroscope.
- X) The leaves close because electrons flow from the electroscope to the rod, resulting in a net positive charge in the electroscope.
- Y) The leaves open because electrons flow from the rod to the electroscope, resulting in a net negative charge in the electroscope.
- Z) The leaves open because electrons flow from the electroscope to the rod, resulting in a net positive charge in the electroscope.

**Toss Up Answer: Y**

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**Bonus: Short Answer**

A positive charge of  $+5.3 \text{ Coulombs}$  is placed in an electric field of  $420 \text{ Newtons per Coulomb}$ . Find the magnitude of the force the charge experiences in this electric field, rounded to two significant figures.

**Bonus Answer: 2200 N (Explanation:  $F = E \cdot q$ )**

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**36. PHYSICS****Toss Up: Multiple Choice**

A constant force acting on a body experiencing no change in its environment will give the body:

- W) constant acceleration
- X) constant speed
- Y) constant velocity

Z) zero acceleration

**Toss Up Answer: W**

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**Bonus: Multiple Choice**

What is the MOST common term for the inwardly directed force exerted on an object to keep the object moving in a circle?

W) Centripetal Acceleration

X) Friction

Y) Normal Force

Z) Centripetal Force

**Bonus Answer: Z**

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### 37. PHYSICS

**Toss Up: Short Answer**

The Kondo effect describes this quantity's divergence at low temperatures. Strain gauges operate by detecting changes in this quantity, because it is proportional to length and inversely proportional to cross-sectional area. Its AC-circuit extension is the complex quantity impedance, and its inverse, measured in siemens, is the conductance. Equal to voltage divided by current, according to Ohm's law, it is high for insulators and low for conductors. Name this measure of how much an object opposes electric current.

**Bonus Answer: Resistance**

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**Bonus: Short Answer**

What's the emf in volts produced by an inductor with an inductance of 0.3 henry and a current with equation  $I(t) = 2t^2 + 2$  after 3 seconds of operation?

**Bonus Answer: 3.6 volts**

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### 38. PHYSICS

**Toss Up: Multiple Choice**

What's the critical angle in radians when a ray passes from a medium with index of refraction of 1.4 to a medium with index of refraction of 0.7?

W)  $\pi/2$

X)  $\pi/3$

Y)  $\pi/6$

Z)  $\pi$

**Toss Up Answer: Y**

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**Bonus: Short Answer**

A concave spherical mirror has a focal length of 12 cm. If an object is placed 6 cm in front of it the image position is:

**Bonus Answer: 12cm behind the mirror (accept -12cm)**

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### 39. PHYSICS

**Toss Up: Short Answer**

Given  $G$  as the gravitational constant and there exists an equilateral triangle with side length " $a$ " and identical objects with mass of " $x$ " what is the total gravitational potential energy of an object with mass " $y$ " that is located at the center?

**Bonus Answer:  $-G(xy) \frac{3\sqrt{3}}{a}$**

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**Bonus: Multiple Choice**

Given  $G$  as the gravitational constant and there exists an equilateral triangle with side length " $a$ " and identical objects

with mass of "x" what is the total gravitational potential energy of this system?

W)  $-9\sqrt{3}G(xy)/a$  (read as negative nine times square root of 3 times G times the second power of x divided by a)

X)  $-3\sqrt{3}G(x^2)/a$  (read as negative three times square root of 3 times G times the second power of x divided by a)

Y)  $-3G(x^2)/a$  (read as negative three times G times the second power of x divided by a)

Z)  $-\sqrt{3}G(x^2)/a$  (read as negative square root of 3 times G times the second power of x divided by a)

**Bonus Answer: Y**

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## 40. PHYSICS

**Toss Up: Multiple Choice**

A closed hemispherical shell of radius R is filled with fluid at uniform pressure p. The net force of the fluid on the curved portion of the shell is given by:

W)  $2\pi R^2 p$  (read as 2 pi times R squared times p)

X)  $4\pi R^2 p$  (read as 4 pi times R squared times p)

Y)  $\pi R^2 p$  (read as pi times R squared times p)

Z)  $(4/3)\pi R^2 p$  (read as 4 over 3 times pi times R squared times p)

**Toss Up Answer: Y**

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**Bonus: Short Answer**

A boat floating in fresh water displaces 16,000N of water. How many newtons of saltwater would it displace if it floats in saltwater of specific gravity 1.17?

**Bonus Answer: 16,000**

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## 41. PHYSICS

**Toss Up: Short Answer**

The quantity epsilon naught multiplied by the time derivative of electric flux represents what quantity in the Maxwell-Ampere equation?

**Bonus Answer: Displacement current**

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**Bonus: Short Answer**

In a solenoid of length 20m with a current of 10 amperes traveling through it and undergoes 20 turns what is the magnitude of the magnetic field within it in teslas? Assume the vacuum permittivity is  $9 \times 10^{-12}$  and PI is approximately 3.

**Bonus Answer:  $1.8 \times 10^{-9}$  teslas**

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## 42. PHYSICS

**Toss Up: Short Answer**

In a spherical shell with radius of 2 meters a magnetic field with strength of 2 teslas passes through. What is the net magnetic flux?

**Bonus Answer: 0**

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**Bonus: Short Answer**

What is the magnitude of the induced current produced as the magnetic field passing through a circle with radius of 2m and resistance of 5 ohms changes from 50 teslas to 25 teslas in 5 seconds to the nearest whole number?

**Bonus Answer: 13 amperes**

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## 43. PHYSICS

**Toss Up: Multiple Choice**

Which of the following is the most accurate? The center of mass of the system consisting of Earth, the Sun, and the planet Mars is:

- W) closer to the Sun than to either of the other bodies
- X) closer to Earth than to either of the other bodies
- Y) at the geometric center of the triangle formed by the three bodies
- Z) at the center of the line joining Earth and Mars

**Toss Up Answer: W**

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**Bonus: Multiple Choice**

At the same instant that a 0.50-kg ball is dropped from 25m above Earth, a second ball, with a mass of 0.25 kg, is thrown straight upward from Earth's surface with an initial speed of 15m/s. They move along nearby lines and pass each other without colliding. At the end of 2.0 s the height above Earth's surface of the center of mass of the two-ball system is:

- W) 3.0m
- X) 5.0m
- Y) 6.5m
- Z) 7.1m

**Bonus Answer: Z**

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**44. PHYSICS**

**Toss Up: Short Answer**

What is the torque in N\*m (read as newton meters) acting on a disk with radius of 3 meters, mass of 5kg, and rotating with an angular acceleration of 10 rad/s<sup>2</sup>?

**Bonus Answer: 225 N\*m**

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**Bonus: Short Answer**

If a sphere with radius of 4 meters and a mass of 5kg is rolling at a velocity of 12m/s, find the total energy of the sphere in joules.

**Bonus Answer: 648 J**

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**45. PHYSICS**

**Toss Up: Short Answer**

Rank following electromagnetic radiations according to the energies of their photons, from least to greatest:

1. blue light
2. yellow light
3. x rays
4. radio waves

**Bonus Answer: 4, 2, 1, 3 (accept equivalent forms)**

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**Bonus: Multiple Choice**

The work function for a certain sample is 2.3 eV. The stopping potential for electrons ejected from the sample by  $7.0 \times 10^{14}$ -Hz electromagnetic radiation is:

- W) 0 V
- X) 0.6 V
- Y) 2.3 V
- Z) 5.2 V

**Bonus Answer: Y**

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## 46. PHYSICS

### Toss Up: Multiple Choice

Which is the weakest fundamental force?

- W) The color force
- X) The weak force
- Y) Electromagnetism
- Z) Gravity

**Toss Up Answer: Z**

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### Bonus: Short Answer

Identify all of the following that are false:

1. Neutrinos travel at speed  $C$
2. The strength of the color force can increase with distance
3. Electrons have color charge
4. All baryons are unstable

**Bonus Answer: 1, 3, 4**

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## 47. PHYSICS

### Toss Up: Short Answer

What is the name of the five points in a two body system where a small object can remain gravitationally stable?

**Bonus Answer: lagrange points**

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### Bonus: Multiple Choice

Which of the following is the major contributor to an atom's mass?

- W) the weak force
- X) the strong force
- Y) quarks
- Z) the higgs boson

**Bonus Answer: X**

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## 48. PHYSICS

### Toss Up: Short Answer

A gear with 40 teeth turns clockwise at 200 revolutions per minute. This gear is driving another gear with 20 teeth, which in turn is driving another gear with 80 teeth. How fast is the third gear going, and in what direction?

**Bonus Answer: 100 revolutions per minute clockwise**

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### Bonus: Multiple Choice

A diverging lens produces an image of an object that is:

- W) virtual, smaller, and upright
- X) virtual, larger, and upright
- Y) real, smaller, and upside down
- Z) real, larger, and upright

**Bonus Answer: W**

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## 49. PHYSICS

### Toss Up: Multiple Choice

Which of the following is NOT a state variable?

- W) Work
- X) Heat
- Y) Entropy
- Z) Pressure

**Toss Up Answer: W**

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**Bonus: Short Answer**

During an isobaric process, 80 joules of work is done on the surroundings by the gas. How much energy is added in joules?

**Bonus Answer: 200 joules**

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**50. PHYSICS**

**Toss Up: Short Answer**

A certain heat engine draws 500 cal/s from a water bath at 27° C and transfers 400 cal/s to a reservoir at a lower temperature. The efficiency of this engine is:

**Bonus Answer: 20%**

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**Bonus: Multiple Choice**

An Carnot refrigerator runs between a cold reservoir at temperature TC and a hot reservoir at temperature TH. You want to increase its coefficient of performance. Of the following, which change results in the greatest increase in the coefficient? The value of  $\Delta T$  is the same for all changes.

- W) Raise the temperature of the hot reservoir by  $\Delta T$
- X) Raise the temperature of the cold reservoir by  $\Delta T$
- Y) Lower the temperature of the hot reservoir by  $1/2 \Delta T$  and raise the temperature of the cold reservoir by  $1/2 \Delta T$
- Z) Lower the temperature of the cold reservoir by  $\Delta T$

**Bonus Answer: X**

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**51. PHYSICS**

**Toss Up: Multiple Choice**

Find the angular frequency of oscillations in a LC circuit if the total inductance is 2 henry and the total capacitance is 8 farad.

- W) 1/4
- X) 1/2
- Y) 1/3
- Z) 1/5

**Toss Up Answer: W**

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**Bonus: Short Answer**

An LC circuit has an inductance of 20mH and a capacitance of 5.0  $\mu$ F. At time  $t = 0$  the charge on the capacitor is 3.0  $\mu$ C and the current is 7.0mA. The total energy in joules is:

**Bonus Answer:  $9.0 \times 10^{-7}$  (accept equivalent forms)**

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**52. PHYSICS**

**Toss Up: Multiple Choice**

A transverse traveling sinusoidal wave on a string has a frequency of 100Hz, a wavelength of 0.040m, and an amplitude of 2.0mm. The maximum velocity in m/s of any point on the string is

- W) 0.2
- X) 1.3
- Y) 4



Z) 15

**Toss Up Answer: X**

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**Bonus: Multiple Choice**

The time required for a small pulse to travel from A to B on a stretched cord shown is NOT altered by changing

- W) the linear mass density of the cord
- X) the length between A and B
- Y) the shape of the pulse
- Z) the tension in the cord

**Bonus Answer: Y**

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## 53. PHYSICS

**Toss Up: Multiple Choice**

In order for two sound waves to produce audible beats, it is essential that the two waves have:

- W) the same amplitude
- X) slightly different amplitudes
- Y) the same number of harmonics
- Z) slightly different frequencies

**Toss Up Answer: Z**

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**Bonus: Multiple Choice**

A 200-cm organ pipe with one end open is in resonance with a sound wave of wavelength 270cm. The pipe is operating in its

- W) fundamental frequency
- X) second harmonic
- Y) third harmonic
- Z) fourth harmonic

**Bonus Answer: X**

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## 54. PHYSICS

**Toss Up: Multiple Choice**

The zeroth law of thermodynamics allows us to define:

- W) work
- X) pressure
- Y) temperature
- Z) thermal equilibrium

**Toss Up Answer: Y**

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**Bonus: Short Answer**

Which physicist contributed to the understanding of electrical circuits and coined the term "black body" radiation?

**Bonus Answer: Kirchoff**

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## 55. PHYSICS

**Toss Up: Multiple Choice**

The rate of heat flow by conduction through a slab does NOT depend upon the

- W) temperature difference between opposite faces of the slab

- X) thermal conductivity of the slab
- Y) slab thickness
- Z) specific heat of the slab

**Toss Up Answer: Z**

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**Bonus: Multiple Choice**

Inside a room at a uniform comfortable temperature, metallic objects generally feel cooler to the touch than wooden objects do. This is because:

- W) a given mass of wood contains more heat than the same mass of metal
- X) metal conducts heat better than wood
- Y) the equilibrium temperature of metal in the room is lower than that of wood
- Z) the human body, being organic, resembles wood more closely than it resembles metal

**Bonus Answer: X**

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**56. PHYSICS**

**Toss Up: Multiple Choice**

Sound waves can propagate through a plasma because of:

- W) high coulomb interactions between particles
- X) high density of particles
- Y) high energy of particles
- Z) high kinetic pressure force

**Toss Up Answer: W**

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**Bonus: Short Answer**

Which description(s) of plasma is most often used to understand the macroscopic features of plasma: Single particle theory, kinetic theory, fluid description

**Bonus Answer: Fluid description**

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**57. PHYSICS**

**Toss Up: Short Answer**

In a well-known physical experiment, two small masses were suspended by a thread, each positioned near two much larger stationary masses. A mirror was used to measure the angle through which the thread twists due to the rotation of the small masses' movement. Which physicist conducted this experiment, and what constant did he/she derive from it?

**Bonus Answer: Henry Cavendish (accept "Cavendish") and Universal gravitational constant (accept "big G", don't accept "gravity" or just "g")**

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**Bonus: Short Answer**

A skydiver leaps from a plane at a high altitude. Given acceleration due to gravity is equal to 10 meters per second squared and it takes 45 seconds for the skydiver to fall, calculate the height at which the skydiver fell from, rounded to the nearest thousand meters.

**Bonus Answer: 20000 [Calculation:  $x = a * t^2 = (10 \text{ m/s}^2)(45\text{s})^2 = 20250\text{m} \rightarrow \text{rounded to } 20000$ ]**

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**58. PHYSICS**

**Toss Up: Short Answer**

A parallel circuit has two resistors, one with a resistance of 4 ohms, and the other of 8 ohms. What is the equivalent resistance of the circuit? State the answer as a fraction.

**Bonus Answer: 8/3 ohms**

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**Bonus: Short Answer**

What is the equivalent capacitance of a parallel circuit with capacitors of 8 micro-Farads, 12 micro-Farads, and 15 micro-Farads?

**Bonus Answer: 35 micro-Farads**

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**59. PHYSICS****Toss Up: Short Answer**

It is known that 28 g of a certain ideal gas occupy 22.4 liters at standard conditions. The volume occupied by 42 g of this gas at standard conditions is:

**Bonus Answer: 33.6 liters**

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**Bonus: Multiple Choice**

Use  $R = 8.2 \times 10^{-5} \text{ m}^3 \cdot \text{atm/mol} \cdot \text{K}$  and  $N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$ . The approximate number of air molecules in a 1m<sup>3</sup> volume at 300K and atmospheric pressure is:

W) 41

X) 450

Y)  $2.5 \times 10^{25}$

Z)  $5.4 \times 10^{26}$

**Bonus Answer: Y**

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**60. PHYSICS****Toss Up: Multiple Choice**

A body at rest in a system is capable of doing work if:

W) the potential energy of the system is positive

X) it is free to move in such a way as to decrease the potential energy of the system

Y) it is free to move in such a way as to increase the potential energy of the system

Z) it is free to move in such a way as to decrease its kinetic energy

**Toss Up Answer: X**

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**Bonus: Short Answer**

If the force of a non-linear spring is defined as  $F(x) = 3x^2 + 2x + 5$ , what is the work done on the spring if it's stretched to 3 meters from equilibrium?

**Bonus Answer: 51 J**

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