AP PHYSICS II <u>Golden Rod</u>
For all students taking AP physics II

JANUARY 14, 2016

Directions: For each question or statement fill in the appropriate space on the answer sheet. Use the letter preceding the word, phrase, or quantity which best completes or answers the question. Each of the 25 questions is worth 4 points.

Use: g =10. m/s²

As prescribed by the College Board for AP Physics, the work done *on* a gas is a *positive* quantity; $\Delta U = Q + W$

$c_{water} = 4200\ J/kg\cdot K$, $c_{steam} = 2010\ J/kg\cdot K$, & $c_{ice} = 2090\ J/kg\cdot K$

$c_{copper} = 387\ J/kg\cdot K$, $c_{mercury} = 140\ J/kg\cdot K$, & $c_{air} = 1006\ J/kg\cdot K$

1. Which of the following reduced units represents a unit for pressure?

(A) kg/m^2 (B) $kg\cdot m/s$ (C) $kg/m\cdot s^2$ (D) $kg/m^2\cdot s^2$

2. At a pool party, you pull an inflated beach ball under water by tying a light string around it. The ball has mass ***M*** and an overall specific gravity of 0.25. While you hold the string, and therefore the ball, under water motionless, what is the tension in the string?

(A) Mg (B) $2Mg$ (C) $3Mg$ (D) $4Mg$

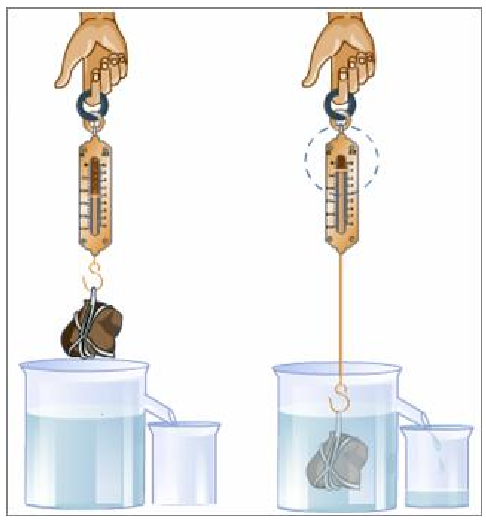
3. A typical human being has a density of approximately $900\ kg/m^3$. As this typical human being floats in fresh water, what percent of his/her body is above water?

(A) 10% (B) 20% (C) 50% (D) 90%

4. Pictured below is a typical physics demonstration. The left image shows a rock of unknown density and composition hanging from a spring scale in air that reads 15 Newtons. The right image is after the rock has been slowly lowered into a beaker of water that is allowed to overflow into a measuring beaker. After the rock is fully submerged, but not touching the bottom of the beaker, the spring scale on the right reads only 10 Newtons and the overflow water container is accidentally knocked over and spilled by an inept lab partner. Based on just the spring scale readings and basic fluid statics, what is the density of the rock?

(A) $200\ kg/m^3$ (B) $300\ kg/m^3$

(C) $2000\ kg/m^3$ (D) $3000\ kg/m^3$

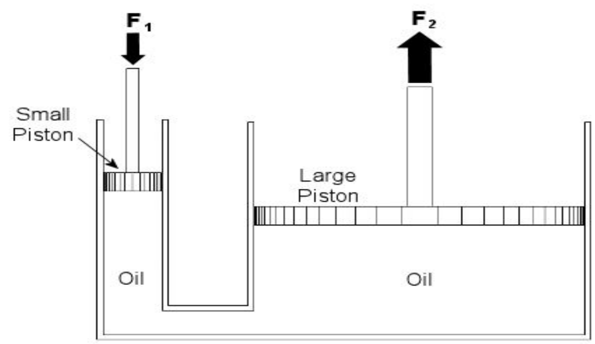


5. Find the minimum mass required for a uniform sphere of radius 10-cm to sink (have nothing showing above the surface) in fresh water.
(A) 0.42 kg (B) 4.2 kg (C) 42 kg
(D) It cannot be determined without knowing the type of material or the density of the material.

6. Hot water leaves your water heater in the basement at a speed of 0.5 m/s through a pipe of diameter 5 cm. By the time it gets to your bathroom sink, the pipe has decreased in size to 1.25 cm radius. How fast does the water leave this faucet?
(A) 0.25 m/s (B) 0.5 m/s (C) 1.0 m/s (D) 2.0 m/s

7. A 200-N force, $\boldsymbol{F_1}$ in diagram below, is exerted on the small "input" piston of a hydraulic lift. The diameter of this input piston is 5-cm. What is the output force, $\boldsymbol{F_2}$, exerted if the output piston has a diameter of 75-cm?

(A) 3,000 N (B) 5,000 N
(C) 15,000 N (D) 45,000 N



Use the following information for questions #8 & #9 : A drinking fountain in your school has the nozzle aimed at 60^{o} above horizontal and the water coming out travels a horizontal distance of 40-cm in a full projectile path, landing at the same height as the nozzle opening.

8. What is the speed at which the water leaves the nozzle?
(A) 1 m/s (B) 2 m/s
(C) 3 m/s (D) 4 m/s

9. If the diameter of the hole in the nozzle is 1-cm, what is the volume rate of flow?
(A) $1.6x10^{-4}\ m^3/s$ (B) $3.2x10^{-4}\ m^3/s$ (C) $4.8x10^{-4}\ m^3/s$ (D) $6.3x10^{-4}\ m^3/s$

10. Your hunting cabin is directly fed by a water tower on a small hill behind it; there is no city water supply. The surface of the water in the large water tank is 25 meters above the level of the faucet in your kitchen. What is the speed of the water exiting your kitchen faucet? Assume $D_{water} = 1000\ kg/m^3$, $D_{air} = 1.3\ kg/m^3$, and $P_{atm} = 1x10^5\ Pa$.
(A) 8 m/s (B) 16 m/s (C) 22.4 m/s (D) 500 m/s

11. A one-kilogram hunk of copper initially at a cool 5°C is removed from a refrigerator and added to one-kilogram of water in an insulated container. The water is initially at a balmy 90°C. Which of the following statements is true once thermal equilibrium is reached within the container?
(A) The thermal energy gained by the copper is greater than the thermal energy lost by the water.
(B) The thermal energy gained by the copper is less than the thermal energy lost by the water.
(C) The temperature change of the copper is greater than the temperature change of the water.
(D) The temperature change of the copper is less than the temperature change of the water.
(E) The temperature change of the copper is the same as the temperature change of the water.

12. The maximum (Carnot) efficiency of a heat engine operating between a high heat of 800°C and a cold reservoir of 50°C is approximately:
(A) 15% (B) 30% (C) 70% (D) 94%

13. Which of the following statements is correct about an ideal gas being isothermally compressed?
(A) Heat flows from the gas to the surroundings.
(B) Heat flows from the surroundings into the gas.
(C) No thermal energy is absorbed or given off by the gas.
(D) The temperature of the gas will increase or decrease depending on the work done on or by the gas.

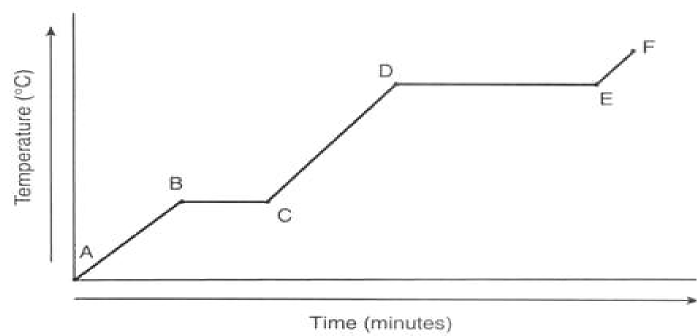
14. After one complete cycle of a Carnot engine, which of the following quantities remains the same?
(A) Work done on the gas.
(B) Internal energy of the gas.
(C) Heat exchanged to and from the surroundings.
(D) This cannot be answered without knowing the efficiency of the heat engine.

Use the following information for questions #15 & #16 : The temperature of three moles of an ideal monatomic gas is reduced from 540 K to 350 K by adding 5500 J of heat to it. R = 8.31J/(mol-K).
15. What is the change in internal energy during this process?
(A) Loss of 7100 J (B) Gain of 7100 J (C) Zero (D) Loss of 5500 J

16. What is the work done on or by the gas during this process?
(A) 12,600 J by the gas (B) 12,600 J on the gas (C) Zero (D) 5500 J by the gas

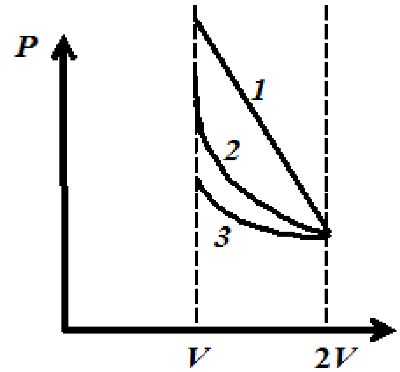
17. How much heat energy must be supplied to 100-g sample of solid ice (H_2O_s) initially at -20°C to raise it to solid ice (H_2O_s) at 0°C?
(A) $8.4x10^6\ J$ (B) $4.2x10^6\ J$ (C) $8.4x10^3\ J$ (D) $4.2x10^3\ J$

18. The sketch below represents the "heating curve" of an unknown solid; temperature in °C versus time in minutes. Thermal energy is added to a sample initially in solid phase at a constant rate starting at ***t*** = 0. Which statement below best explains the meaning of the plateaus on the graph, B→C and D→E?



(A) Heat is being given off to the environment.
(B) Heat is being stored within the solid in a different form.
(C) This is where phase changes are taking place.
(D) This is where heat conduction occurs; heat is transferred to other parts of the material.

Use the following information for questions #19 - #21 : The graph below represents the ***P-V*** diagram for an ideal gas that is taken from three different initial states that all end at the same point where the final volume is twice the initial volume. Three individual processes are shown and each takes the gas to the same end point. Process 2 is *adiabatic* and Process 3 is *isothermal*.

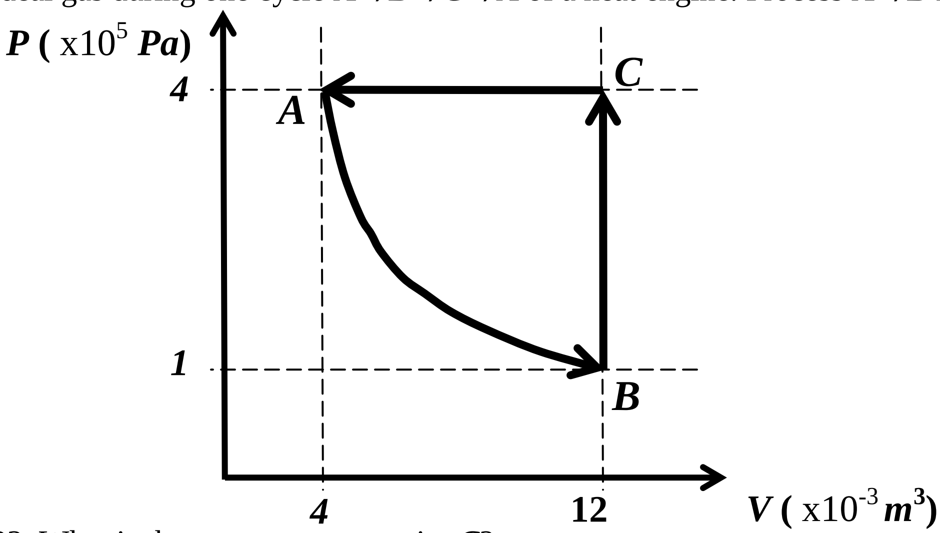


19. Which process represents the greatest work done by the gas?
(A) Process 1 (B) Process 2
(C) Process 3 (D) All three processes are equal.

20. Which process results in the greatest temperature change of the gas?
(A) Process 1 (B) Process 2
(C) Process 3 (D) All three processes are equal.

21. Which process results in no change in internal energy?
(A) Process 1 (B) Process 2
(C) Process 3 (D) All three processes change the internal energy.

Use the following information for questions #22 - #24 : The PV diagram below represents another monatomic ideal gas during one cycle **A→B→C→A** of a heat engine. Process **A→B** is an isotherm at 190 ***K***.



22. What is the temperature at point ***C***?
(A) 190 K (B) 380 K (C) 570 K (D) 760 K

23. How much work is done on or by the gas in process **C→A**?
(A) 32 *J* on the gas (B) 32 *J* by the gas (C) 3200 *J* on the gas (D) 3200 *J* by the gas

24. For each complete cycle **A→B→C→A**, the net work done is
(A) positive (B) negative (C) zero (D) Can't tell without more information.

25. A heat engine is designed for the purpose of lifting a 20-kg object at a constant speed of 8 m/s. The engine operates between the temperatures of 500 K and 300 K. If this engine operates at maximum efficiency, what is the rate at which heat is exhausted to the cold reservoir?
(A) 1600 W (B) 2400 W (C) 3200 W (D) 4000 W

AP I and AP 2 PHYSICS FORMULAE Updated 12-23-2015

Constants & Conversion Factors

Proton and Neutron Mass	$m_p = 1.67x10^{-27}\,kg$	Fundamental charge	$e = 1.6x10^{-19}\,C$
Electron Mass	$m_e = 9.11x10^{-31}\,kg$	Electron Volt	$1eV = 1.6x10^{-19}\,J$
Avogadro's #	$6.02x10^{23}\,mol^{-1}$	Universal Gravitational constant	$G = 6.67x10^{-11}\,Nm^2/kg^2$
Universal gas constant	$R = 8.31\,J/mol\cdot K$	Speed of Light	$c = 3.00x10^8\,m/s$
Boltzmann's constant	$k_B = 1.38x10^{-23}\,J/K$	Magnetic constant	$k' = 1x10^{-7}\,T\cdot m/A$
1 unified atomic mass unit		$1u = 1.66x10^{-27}\,kg = 931\,MeV/c^2$	
Planck's Constant		$h = 6.63x10^{-34}\,J\cdot s = 4.14x10^{-15}\,eV\cdot s$ $hc = 1.99x10^{-25}\,J\cdot m = 1240\,eV\cdot nm$	
Coulomb's Law constant		$k = \frac{1}{4\pi\varepsilon_o} = 9.0x10^9\,N\cdot m^2/kg^2$ $\varepsilon_o = 8.85x10^{-12}\,C^2/N\cdot m^2$	

MECHANICS

$\bar{v} = \frac{\Delta x}{\Delta t}$

$\bar{a} = \frac{\Delta v}{\Delta t}$

$v_f = v_i + at$

$\Delta x = v_i t + \frac{1}{2}at^2$

$2a\Delta x = v_f^2 - v_i^2$

$\Sigma F = ma$

$W = mg$

$F_g = G\frac{m_1 m_2}{r^2}$

$U_g = G\frac{m_1 m_2}{r}$

$\rho = mv$

$F\Delta t = m\Delta v$

$\mu = \frac{F_f}{F_N}$

Δx = displacement (change of position)
$\bar{v}$ = average velocity
$\bar{a}$ = average acceleration
v_i = initial velocity
v_f = final velocity
F = force
F_f = force of friction
F_N = normal force
F_g = gravitational force
G = Universal Gravitational Constant
ρ = momentum
μ = coefficient of friction
r = distance between center of masses
W = weight
m = mass
U_g = gravitational PE

ELECTRICITY

$F_e = k\frac{q_1 q_2}{r^2}$

$E = \frac{F}{q}$

$\Delta U_E = q\Delta V$

$V = \frac{W}{q} = Ed$

$I = \frac{\Delta q}{\Delta t}$

$V = IR$

$P = VI = I^2 R = \frac{V^2}{R}$

SERIES CIRCUIT

$I_T = I_1 = I_2 = I_3 = \ldots$

$V_T = V_1 + V_2 + V_3 + \ldots$

$R_T = R_1 + R_2 + R_3 + \ldots$

PARALLEL CIRCUITS

$I_T = I_1 + I_2 + I_3 + \ldots$

$V_T = V_1 = V_2 = V_3 = \ldots$

$R_T = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots}$

C = Capacitance
E = electric field intensity
I = electric current
k = electrostatic constant
P = Power
q = charge
R = resistance
U_E = electric potential Energy
U_C = energy stored in capacitor
V = electric potential difference
W = Work

$C = Q/\Delta V$

$U_C = \frac{1}{2}Q\Delta V = \frac{1}{2}C\Delta V^2$

$C_{parallel} = \Sigma C_i$

$C_{series} = \frac{1}{\Sigma\left(\frac{1}{C_i}\right)}$

ENERGY AND WORK

$W = F\Delta x\cos\theta$

$P = \frac{W}{\Delta t} = \frac{\Delta E}{\Delta t} = Fv$

$PE_g = mgh$

$KE = \frac{1}{2}mv^2$

$F = -kx$

$PE_s = \frac{1}{2}kx^2$

h = height
k = spring constant
KE = kinetic energy
PE_g = gravitational potential energy
PE_s = potential energy stored in a spring
P = power
W = work
x = change in spring length from the equilibrium position

CIRCULAR MOTION & ROTATION

$a_c = \frac{v^2}{r}$

$F_c = m\frac{v^2}{r}$

$1rev = 2\pi rad = 360°$

$\tau = Fxr = I\alpha$

$I = \Sigma mr^2$

$L = I\omega$

$K_{rot} = \frac{1}{2}I\omega^2$

$x = A\cos(\omega t)$

$x = A\cos(2\pi ft)$

a_c = centripetal acceleration
F_c = centripetal force
τ = Torque
I = Rotational Inertia
α = Angular acceleration
ω = Angular velocity
K_{rot} = Rotational KE
x = position

HEAT AND THERMODYNAMICS

$Q = mc\Delta T$

$Q = mL_f$

$Q = mL_V$

$\Delta L = \alpha L_o \Delta T$

$\frac{Q}{\Delta t} = \frac{kA\Delta T}{L}$

$PV = nRT = NkT$

$K = \frac{3}{2}k_B T$

$\Delta U = \frac{3}{2}nR\Delta T$

$W = -P\Delta V$

$\Delta U = Q + W$

c = specific heat
L_f = latent heat of fusion
L_V = latent heat of vaporization
Q = amount of heat
ΔT = change in temperature
α = coefficient of linear expansion
L_o = original length
$c_{water} = 4186 \frac{J}{kg°K}$
K = kinetic energy
L = thickness
U = internal energy
W = work done on a system

WAVE PHENOMENA & SHM

$T = \frac{1}{f}$

$v = f\lambda$ OR $= \nu\lambda$

$n = \frac{c}{v}$

$n_i \sin\theta_i = n_r \sin\theta_r$

$\lambda = \frac{xd}{L}$

$\sin\theta_c = \frac{1}{n}$

$T_S = 2\pi\sqrt{\frac{m}{k}}$

$T_P = 2\pi\sqrt{\frac{L}{g}}$

c = speed of light in a vacuum
d = distance between slits
$f = \nu$ = frequency
L = distance from slit to screen
n = index of absolute refraction
T = period
v = speed
x = distance from central maximum to first-order maximum
λ = wavelength
θ = angle
θ_c = critical angle relative to air

GEOMETRIC OPTICS & SOUND

$\frac{1}{f} = \frac{1}{d_i} + \frac{1}{d_o}$

$\frac{h_i}{h_o} = \frac{d_i}{d_o}$

$\beta = 10\log\frac{I}{I_o}$

f = focal length
d_i = image distance
d_o = object distance
h_o = object size
h_i = image size
β = Sound level
I = Sound Intensity
I_o = Threshold Intensity

ELECTROMAGNETIC APPLICATIONS

$F_M = Bqv$

$F_M = BIL$

$\varepsilon = BLv$

$\frac{N_P}{N_S} = \frac{V_P}{V_S}$

$V_P I_P = V_S I_S$ (ideal)

$efficiency = \frac{V_S I_S}{V_P I_P}$

$\phi_B = B \cdot A$

$\Delta\phi_B = \varepsilon t$

B = magnetic field strength
I_P = current in primary
I_S = current in secondary
N_P = number of turns in primary coil
N_S = number of turns in secondary coil
V_P = voltage of primary
V_S = voltage of secondary
L = length of conductor
V = electric potential difference
v = speed of particle

FLUID MECHANICS

$\rho = \frac{m}{V}$

$P = \frac{F}{A}$

$P = P_o + mgh$

$F_b = \rho V g$

$A_1 v_1 = A_2 v_2$

$P_1 + \rho g y_1 + \frac{1}{2}\rho v_1^2 =$

$= P_2 + \rho g y_2 + \frac{1}{2}\rho v_2^2$

A = Area
F = force
h = depth
P = pressure
V = volume
v = speed
y = height
ρ = density

MODERN PHYSICS

$E = hf$

$K_{max} = hf - \phi$

$\lambda = \frac{h}{p}$

$E = mc^2$

E = energy
f = frequency
K = kinetic energy
m = mass
p = momentum
λ = wavelength
ϕ = work function

AP PHYSICS II **Golden Rod**

JANUARY 14, 2016

SOLUTIONS (Corrections)

1. C	14. B
2. C	15. A
3. A	16. A
4. D	17. D
5. B	18. C
6. D	19. A
7. D	20. A
8. B	21. D (C)
9. A	22. D and C
10. C	23. C
11. C	24. A
12. C	25. B
13. A	

PHYSICS II: for all students currently enrolled in AP physics II. 25 multiple choice questions per exam.

January: Heat & Thermodynamics, Fluid Statics and Dynamics

February: Electrostatics: electric force, fields, & potential, DC Circuits and RC Circuits, plus January Topics

March: Magnetics and Electromagnetic induction, Geometric & Physical optics, plus Jan and Feb Topics

April: Quantum physics, atomic and nuclear physics, plus Jan, Feb and March topics.

Dates for 2016 Season

Thursday January 14, 2016 Thursday February 11, 2016

Thursday March 10, 2016 Thursday April 14, 2016

New Jersey Science League

PO Box 65 Stewartsville, NJ 08886-0065

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www:entnet.com/~personal/njscil/html

PLEASE RETURN THE AREA RECORD AND ALL TEAM MEMBER SCANTRONS(ALL STUDENTS PLACING 1ST, 2ND, 3RD, AND 4TH).

If you return scantrons of alternates, then label them as ALTERNATES.

Dates for 2017 Season

Thursday January 12, 2017 Thursday February 9, 2017

Thursday March 9, 2017 Thursday April 13, 2017

AP PHYSICS II <u>Golden Rod</u>
For all students taking AP Physics II
Feb 11, 2016

Directions: For each question or statement fill in the appropriate space on the answer sheet. Use the letter preceding the word, phrase, or quantity which best completes or answers the question. Each of the 25 questions is worth 4 points. ***Use: g =10. m/s²*****.** **As prescribed by the College Board for AP Physics, the work done** ***on*** **a system is a** ***positive*** **quantity.**

1. Which of the following represents a unit for electric field strength reduced to SI base units?

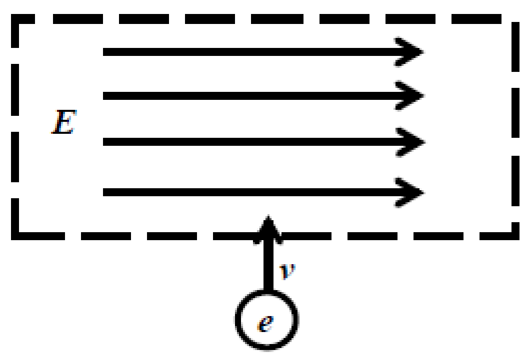
(A) $\frac{kg \cdot m}{A \cdot s}$ (B) $\frac{kg \cdot m}{A \cdot s^2}$ (C) $\frac{kg \cdot m^2}{A \cdot s^2}$ (D) $\frac{kg \cdot m}{A \cdot s^3}$

2. By convention, the direction of an electric field is
(A) in the direction an electron would experience a force due to the electric field.
(B) always perpendicular to the velocity vector of a moving charge.
(C) in the direction a proton would experience a force due to the electric field.
(D) always parallel to the direction of motion of a charged particle.

3. Three resistors, ***A***, ***B***, & ***C***, each made from the same material and each having the same length, are connected in series to a single battery of terminal voltage ***V***. Resistor ***B*** has a cross section twice that of resistor ***A*** and Resistor ***C*** has a cross section twice that of resistor ***B***. Which of the following quantities has the same value for each resistor?
(A) Potential difference (B) Current (C) Resistance (D) Current per unit cross-sectional area

4. A positive point charge of $3nC$ is placed inside a uniform electric field of magnitude $4{,}000\ {}^{N}\!/_{C}$ pointing due north. After the point charge is forced to moved southward a distance of 2 meters, what is the work done by the electric force on the charge?
(A) $2.4x10^{-5}J$ (B) $-2.4x10^{-5}J$ (C) $6x10^{-6}J$ (D) $-6x10^{-6}J$

Use the following for questions #5 & #6: A single electron is injected into a region with a uniform electric field directed to the right of the page. The electron has a constant vertical velocity of ***v*** before entering the electric field.



5. Which of the following describes the path of the electron after entering the region with the electric field?
(A) It will feel a force to the right and follow a circular path.
(B) It will feel a force to the left and follow a parabolic path.
(C) It will feel a force to the left and follow a circular path.
(D) It will feel a force to the right and follow a parabolic path.

6. Assuming the mass and charge of the electron is ***m*** and ***e*** respectively, which of the following expressions correctly states the magnitude of the acceleration of the electron inside the electric field?

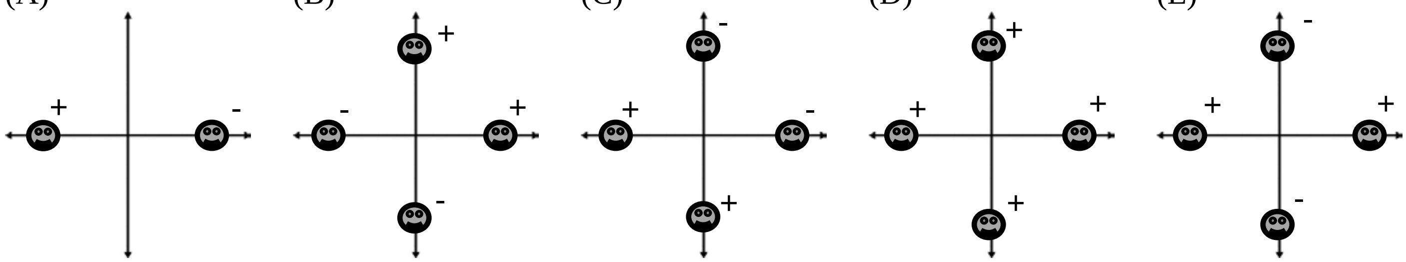
(A) $\frac{eE}{m}$ (B) $\frac{em}{E}$ (C) $\frac{E}{me}$ (D) $\frac{e}{mE}$

7. The *emf*, *ε*, of your car battery is 14 V. However, when you start your car on a cold day, it delivers 800 Amperes and the potential difference between the terminals is measured at only 12 V. Under these conditions, what is the internal resistance of the battery?

(A) 0.0025 Ω (B) 0.0175 Ω (C) 0.015 Ω (D) 400 Ω

Use the following information for questions #8 - 10 : The following five diagrams represents charge distributions on an *xy*-axis with either two or four point charges of equal magnitude and having signs and positions as indicated. All of the charges are the same distance from the origin. Electric potential is defined as zero at an infinite distance from the origin. *Each question #8-10 has* **<u>five choices</u>**.

(A) (B) (C) (D) (E)



8. Which configuration of charges above yields an electric field strength *and* electric potential of **<u>zero</u>** at the origin?

(A) A (B) B (C) C (D) D (E) E

9. Which configuration of charges above yields the largest magnitude electric potential at the origin?

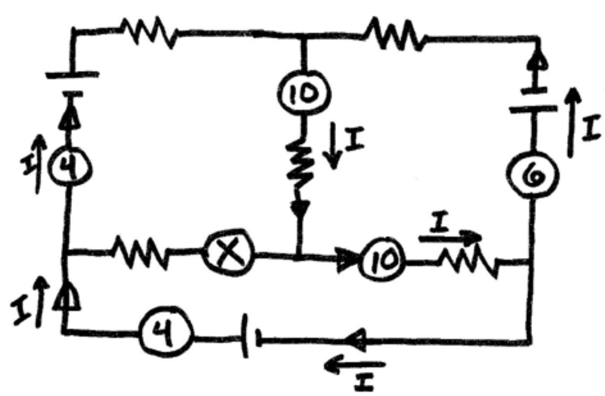
(A) A (B) B (C) C (D) D (E) E

10. Which configuration of charges above is the value of the electric field at the origin **<u>not zero</u>**, but the electric potential at the **<u>origin is zero</u>**?

(A) A only (B) B & C only (C) A, B, & C only (D) A & E only (E) No configuration

11. The circuit shown below indicates only the direction of the conventional current and the ammeter readings in each branch in amperes designated by the circles with the only unknown ammeter reading designated as (X). What is the reading of ammeter (X)?

NOTE: The symbol "**I**" is only a label to designate the direction of the current, *NOT* to indicate magnitude.



(A) Zero (B) 4 A

(C) 6 A (D) 10 A

12. A battery supplies a constant voltage across a copper wire. Which of the following should be increased to cause an increase in the power dissipated by the wire?

(A) The resistivity of the tungsten (B) The cross-sectional area of the wire

(C) The length of the wire (D) The temperature of the wire

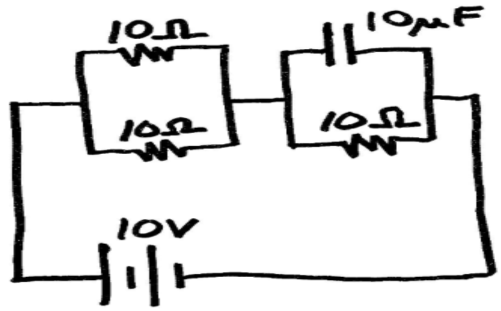
13. During a physics lab activity, you connect a 3-MΩ resistor to a 6-KV potential difference for 2 minutes. What is the quantity of **<u>heat</u>** produced by the resistor in this time?

(A) 0.24 *J* (B) 24 *J* (C) 144 *J* (D) 1440 *J*

14. A piece of well-insulated copper wire is cut into eight equal lengths and then are bundled together and braided side-by-side as shown below, albeit with more wires than shown. When the bare wire ends are twisted together, compared to the resistance ***R*** of the original length of wire, what is the resistance of this shorter braided wire? (Image courtesy of *WikiCommons*)

(A) R (B) $R/4$ (C) $R/16$ (D) $R/64$

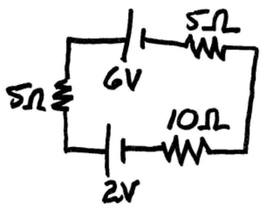
15. The circuit shown below is composed of one battery with *emf* of 10-V and negligible internal resistance, three identical 10-Ω resistors, and one 10-μF capacitor. What is the charge stored in the capacitor after the *emf* of 10-V is maintained for a sufficient time to fully charge the capacitor?



(A) $23\mu C$ (B) $40\mu C$
(C) $67\mu C$ (D) $150\mu C$

16. The circuit shown below right includes two batteries of negligible internal resistance connected in opposition and three resistors. What is the magnitude and direction of the conventional current in the circuit?

	Magnitude	***Direction***
(A)	$0.2A$	Clockwise
(B)	$0.2A$	Counterclockwise
(C)	$0.4A$	Clockwise
(D)	$0.4A$	Counterclockwise



17. For a Lab activity in physics class, you are provided a constant voltage source and three unequal resistors such that $R_1 > R_2 > R_3$. Your task is to combine these three resistors in such a way that, after connection to the battery, they will heat a given quantity of water. Which description below would give the **most rapid heating**?

(A) Connecting all three resistors in series then submerging them in the water.
(B) Connecting the two smaller resistors, R_2 & R_3, in parallel, then placing them in series with the largest one, R_1, then submerging them in the water.
(C) Connecting the two larger resistors, R_1 & R_2, in parallel, then placing them in series with the smallest one, R_3, then submerging them in the water.
(D) Connecting all three resistors in parallel then submerging them in the water.

Use the following information for Questions #18 & 19: An immersion heater, pictured below, is essentially a water-proof resistor that can heat liquids quickly by submerging it. One such heater is powered by a 96-V DC source and contains an 8-Ω resistor.

18. What is the **power** produced by this heater?

(A) $12W$ (B) $768W$ (C) $1152W$ (D) $74KW$

19. Using this heater, how much **time** in seconds is required to bring 1722 *ml* of water initial at 20°C to a boil? The specific heat of water is $4180\ J/kg \cdot K$

(A) 500 seconds (B) 750 seconds (C) 1000 seconds (D) 1250 seconds

Use the following information for questions #20 & #21: A large 2-kg solid ball is dropped from rest from a height of 10-m. After it bounces from the rigid floor, it reaches a maximum height of 6-m.

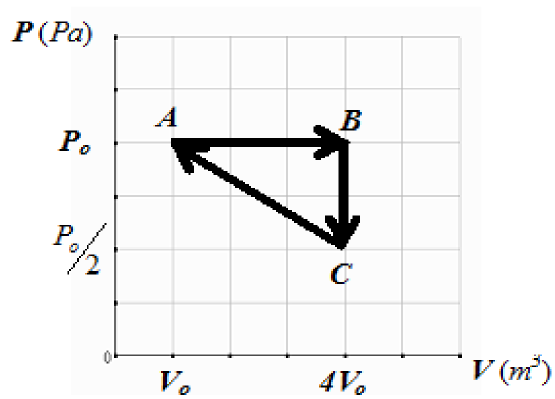
20. What is the specific heat of the material the ball is composed of if the temperature of the ball increases by 0.02°C after it strikes the floor? Assume all mechanical energy "lost" during the bounce causes the temperature change.

(A) $2000\ J/kg \cdot K$ (B) $3000\ J/kg \cdot K$ (C) $4000\ J/kg \cdot K$ (D) $5000\ J/kg \cdot K$

21. If this material the ball is made of has a specific gravity of 1.2, what is the radius of the ball?

(A) 4.0 cm (B) 7.4 cm (C) 8.0 cm (D) 13.6 cm

Use the following information for questions #22 & #23: The following P-V diagram shows an ideal gas undergoing three processes from an initial state labelled ***A***, then taken from ***A→B,*** then ***B→C ,*** and then back to the initial state via ***C→A***.



22. For each complete cycle **A→B→C→A**, the work done on the gas is

(A) P_oV_o (B) $\frac{1}{2}P_oV_o$

(C) $\frac{3}{4}P_oV_o$ (D) $2P_oV_o$

23. If the temperature of the gas at point ***A*** is 100°C, then what is the temperature at point ***C***?

(A) 100^oC (B) 200^oC

(C) 373^oC (D) 473^oC

Use the following information for questions #24 & #25: An object that can float in fresh water has a volume of 0.2 m^3 and a mass of 80 *kg*.

24. What percentage of the object is under the surface of the water it floats in?

(A) 40% (B) 50% (C) 60% (D) 80%

25. What vertically downward force is needed to submerge this object so that it remains motionless with the top surface of the object just under the surface of the water?

(A) 400 *N* (B) 800 *N* (C) 1200 *N* (D) 2000 *N*

AP I and AP 2 PHYSICS FORMULAE Updated 12-23-2015

Constants & Conversion Factors

Proton and Neutron Mass	$m_p = 1.67x10^{-27}\,kg$	Fundamental charge	$e = 1.6x10^{-19}\,C$
Electron Mass	$m_e = 9.11x10^{-31}\,kg$	Electron Volt	$1eV = 1.6x10^{-19}\,J$
Avogadro's #	$6.02x10^{23}\,mol^{-1}$	Universal Gravitational constant	$G = 6.67x10^{-11}\,Nm^2/kg^2$
Universal gas constant	$R = 8.31\,J/mol\cdot K$	Speed of Light	$c = 3.00x10^8\,m/s$
Boltzmann's constant	$k_B = 1.38x10^{-23}\,J/K$	Magnetic constant	$k' = 1x10^{-7}\,T\cdot m/A$
1 unified atomic mass unit		$1u = 1.66x10^{-27}\,kg = 931\,MeV/c^2$	
Planck's Constant		$h = 6.63x10^{-34}\,J\cdot s = 4.14x10^{-15}\,eV\cdot s$ $hc = 1.99x10^{-25}\,J\cdot m = 1240\,eV\cdot nm$	
Coulomb's Law constant		$k = \frac{1}{4\pi\varepsilon_o} = 9.0x10^9\,N\cdot m^2/kg^2$ $\varepsilon_o = 8.85x10^{-12}\,C^2/N\cdot m^2$	

MECHANICS

$\bar{v} = \frac{\Delta x}{\Delta t}$

$\bar{a} = \frac{\Delta v}{\Delta t}$

$v_f = v_i + at$

$\Delta x = v_i t + \frac{1}{2}at^2$

$2a\Delta x = v_f^2 - v_i^2$

$\Sigma F = ma$

$W = mg$

$F_g = G\frac{m_1 m_2}{r^2}$

$U_g = G\frac{m_1 m_2}{r}$

$\rho = mv$

$F\Delta t = m\Delta v$

$\mu = \frac{F_f}{F_N}$

- Δx = displacement (change of position)
- $\bar{v}$ = average velocity
- $\bar{a}$ = average acceleration
- v_i = initial velocity
- v_f = final velocity
- F = force
- F_f = force of friction
- F_N = normal force
- F_g = gravitational force
- G = Universal Gravitational Constant
- ρ = momentum
- μ = coefficient of friction
- r = distance between center of masses
- W = weight
- m = mass
- U_g = gravitational PE

ELECTRICITY

$F_e = k\frac{q_1 q_2}{r^2}$

$E = \frac{F}{q}$

$\Delta U_E = q\Delta V$

$V = \frac{W}{q} = Ed$

$I = \frac{\Delta q}{\Delta t}$

$V = IR$

$P = VI = I^2 R = \frac{V^2}{R}$

SERIES CIRCUIT

$I_T = I_1 = I_2 = I_3 = \ldots$

$V_T = V_1 + V_2 + V_3 + \ldots$

$R_T = R_1 + R_2 + R_3 + \ldots$

PARALLEL CIRCUITS

$I_T = I_1 + I_2 + I_3 + \ldots$

$V_T = V_1 = V_2 = V_3 = \ldots$

$R_T = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots}$

- C = Capacitance
- E = electric field intensity
- I = electric current
- k = electrostatic constant
- P = Power
- q = charge
- R = resistance
- U_E = electric potential Energy
- U_C = energy stored in capacitor
- V = electric potential difference
- W = Work

$C = Q/\Delta V$

$U_C = \frac{1}{2}Q\Delta V = \frac{1}{2}C\Delta V^2$

$C_{parallel} = \Sigma C_i$

$C_{series} = \frac{1}{\Sigma\left(\frac{1}{C_i}\right)}$

ENERGY AND WORK

$W = F\Delta x\cos\theta$

$P = \frac{W}{\Delta t} = \frac{\Delta E}{\Delta t} = Fv$

$PE_g = mgh$

$KE = \frac{1}{2}mv^2$

$F = -kx$

$PE_s = \frac{1}{2}kx^2$

- h = height
- k = spring constant
- KE = kinetic energy
- PE_g = gravitational potential energy
- PE_s = potential energy stored in a spring
- P = power
- W = work
- x = change in spring length from the equilibrium position

CIRCULAR MOTION & ROTATION

$a_c = \frac{v^2}{r}$

$F_c = m\frac{v^2}{r}$

$1rev = 2\pi rad = 360^\circ$

$\tau = Fxr = I\alpha$

$I = \Sigma mr^2$

$L = I\omega$

$K_{rot} = \frac{1}{2}I\omega^2$

$x = A\cos(\omega t)$

$x = A\cos(2\pi ft)$

- a_c = centripetal acceleration
- F_c = centripetal force
- τ = Torque
- I = Rotational Inertia
- α = Angular acceleration
- ω = Angular velocity
- K_{rot} = Rotational KE
- x = position

HEAT AND THERMODYNAMICS

$Q = mc\Delta T$

$Q = mL_f$

$Q = mL_V$

$\Delta L = \alpha L_o \Delta T$

$\frac{Q}{\Delta t} = \frac{kA\Delta T}{L}$

$PV = nRT = NkT$

$K = \frac{3}{2}k_B T$

$\Delta U = \frac{3}{2}nR\Delta T$

$W = -P\Delta V$

$\Delta U = Q + W$

c = specific heat
L_f = latent heat of fusion
L_V = latent heat of vaporization
Q = amount of heat
ΔT = change in temperature
α = coefficient of linear expansion
L_o = original length
$c_{water} = 4186\frac{J}{kg°K}$
K = kinetic energy
L = thickness
U = internal energy
W = work done on a system

WAVE PHENOMENA & SHM

$T = \frac{1}{f}$

$v = f\lambda$ OR $= \nu\lambda$

$n = \frac{c}{v}$

$n_i \sin\theta_i = n_r \sin\theta_r$

$\lambda = \frac{xd}{L}$

$\sin\theta_c = \frac{1}{n}$

$T_S = 2\pi\sqrt{\frac{m}{k}}$

$T_P = 2\pi\sqrt{\frac{L}{g}}$

c = speed of light in a vacuum
d = distance between slits
$f = \nu$ = frequency
L = distance from slit to screen
n = index of absolute refraction
T = period
v = speed
x = distance from central maximum to first-order maximum
λ = wavelength
θ = angle
θ_c = critical angle relative to air

GEOMETRIC OPTICS & SOUND

$\frac{1}{f} = \frac{1}{d_i} + \frac{1}{d_o}$

$\frac{h_i}{h_o} = \frac{d_i}{d_o}$

$\beta = 10\log\frac{I}{I_o}$

f = focal length
d_i = image distance
d_o = object distance
h_o = object size
h_i = image size
β = Sound level
I = Sound Intensity
I_o = Threshold Intensity

ELECTROMAGNETIC APPLICATIONS

$F_M = Bqv$

$F_M = BIL$

$\varepsilon = BLv$

$\frac{N_P}{N_S} = \frac{V_P}{V_S}$

$V_P I_P = V_S I_S$ (ideal)

$efficiency = \frac{V_S I_S}{V_P I_P}$

$\phi_B = B \cdot A$

$\Delta\phi_B = \varepsilon t$

B = magnetic field strength
I_P = current in primary
I_S = current in secondary
N_P = number of turns in primary coil
N_S = number of turns in secondary coil
V_P = voltage of primary
V_S = voltage of secondary
L = length of conductor
V = electric potential difference
v = speed of particle

FLUID MECHANICS

$\rho = \frac{m}{V}$

$P = \frac{F}{A}$

$P = P_o + mgh$

$F_b = \rho Vg$

$A_1 v_1 = A_2 v_2$

$P_1 + \rho g y_1 + \frac{1}{2}\rho v_1^2 =$

$= P_2 + \rho g y_2 + \frac{1}{2}\rho v_2^2$

A = Area
F = force
h = depth
P = pressure
V = volume
v = speed
y = height
ρ = density

MODERN PHYSICS

$E = hf$

$K_{max} = hf - \phi$

$\lambda = \frac{h}{p}$

$E = mc^2$

E = energy
f = frequency
K = kinetic energy
m = mass
ρ = momentum
λ = wavelength
ϕ = work function

AP PHYSICS II <u>Golden Rod</u>

For all students taking AP Physics II

Feb 11, 2016

SOLUTIONS

1. D	14. D
2. C	15. C
3. B	16. B
4. B	17. D
5. B	18. C
6. A	19. A
7. A	20. A
8. E	21. B
9. D	22. C
10. C	23. D
11. A	24. A
12. B	25. C
13. D	

PHYSICS II: for all students currently enrolled in AP physics II. 25 multiple choice questions per exam.

January: Heat & Thermodynamics, Fluid Statics and Dynamics

February: Electrostatics: electric force, fields, & potential, DC Circuits and RC Circuits, plus January Topics

March: Magnetics and Electromagnetic induction, Geometric & Physical optics, plus Jan and Feb Topics

April: Quantum physics, atomic and nuclear physics, plus Jan, Feb and March topics.

Dates for 2016 Season

Thursday February 11, 2016

Thursday March 10, 2016 Thursday April 14, 2016

New Jersey Science League

PO Box 65 Stewartsville, NJ 08886-0065

phone # 908-213-8923 fax # 908-213-9391 email newjsl@ptd.net **Web address:**

www:entnet.com/~personal/njscil/html

PLEASE RETURN THE AREA RECORD AND ALL TEAM MEMBER SCANTRONS(ALL STUDENTS PLACING 1ST, 2ND, 3RD, AND 4TH).

If you return scantrons of alternates, then label them as ALTERNATES.

Dates for 2017 Season

Thursday January 12, 2017 Thursday February 9, 2017

Thursday March 9, 2017 Thursday April 13, 2017

AP PHYSICS II Golden Rod

MARCH 10, 2016

Directions: For each question or statement fill in the appropriate space on the answer sheet. Use the letter preceding the word, phrase, or quantity which best completes or answers the question. Each of the 25 questions is worth 4 points. ***Use: g =10. m/s²*****.** **As prescribed by the College Board for AP Physics, the work done** ***on*** **a system is a** ***positive*** **quantity.**

1. Which of the following represents a unit for magnetic field strength reduced to SI base units?

(A) $\frac{kg}{A \cdot s}$ (B) $\frac{kg}{A \cdot s^2}$ (C) $\frac{kg \cdot A}{s^2}$ (D) $\frac{kg \cdot s}{A^2}$

2. What is the primary difference between the force acting on a charged particle in an electric field and that same particle in a magnetic field?

(A) The only difference is in magnitude of the force acting on the particle caused by the fields.

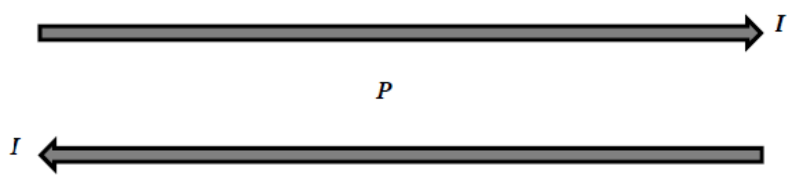
(B) The electric field always causes a force perpendicular to the electric field direction whereas the magnetic field always causes a force parallel to the magnetic field direction.

(C) The magnetic field causes a force perpendicular to the magnetic field direction on the charged particle *only* if the particle moves with a velocity component perpendicular to the magnetic field direction whereas the electric field causes a force only in the direction of the electric field regardless of the motion of the particle.

(D) The magnetic field always causes a force perpendicular to the magnetic field direction whereas the electric field always causes a force parallel to the electric field direction regardless of the motion of the particle.

3. Two long parallel wires have equal conventional currents, but in opposite directions, as shown below. In what direction is the magnetic field caused by the currents at point P, midway between the two wires?

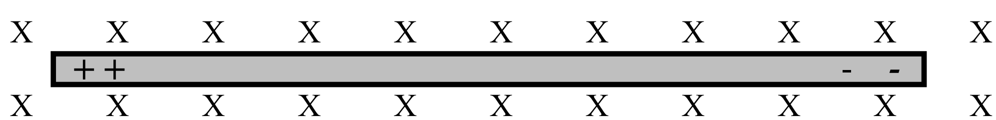
(A) None; there is no magnetic field
(B) Directed into the page
(C) Directed out of the page
(D) Directed to the top of the page



4. A particle of mass ***M***, charge ***Q***, and speed ***V*** moving in a straight path enters a region of uniform magnetic field of strength ***B***. Upon entering the magnetic field, the particle is deflected through a circular path of radius ***R***. What would the radius of the path inside the magnetic field be if the same particle is injected at a linear speed of 2***V***?

(A) $R/4$ (B) $R/2$ (C) $2R$ (D) $4R$

Use the following for questions #5 & #6: A length of straight conducting wire is moving perpendicularly to a uniform magnetic field directed into the page. An induced charge is thus created in the wire; positive to the left and negative to the right, as shown.



5. In what direction is the wire moving?

(A) Upward toward the top of the page. (B) Downward toward the bottom of the page.
(C) To the left of the page. (D) To the right of the page.

6. If you were provided the induced emf, $\boldsymbol{\varepsilon}$, the magnetic field strength, $\boldsymbol{B}$, and the length of wire, $\boldsymbol{L}$, which expression below correctly represents the speed of the wire through the magnetic field?

(A) $\frac{BL^2}{\varepsilon}$ (B) $\frac{BL}{\varepsilon}$ (C) $\frac{\varepsilon}{BL^2}$ (D) $\frac{\varepsilon}{BL}$

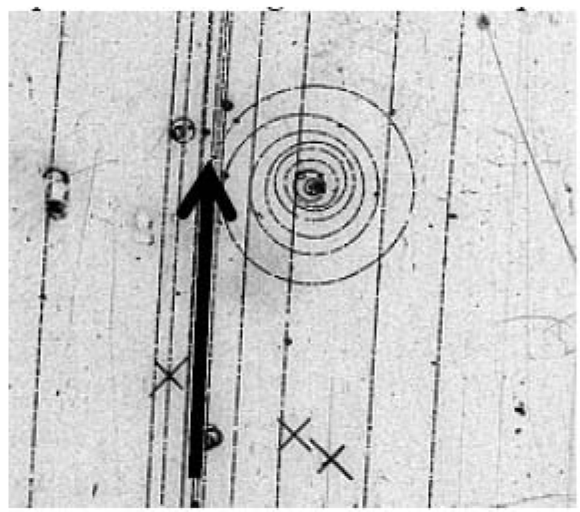
7. An electron is moving vertically upward relative to the surface of the Earth in a region where the Earth's magnetic field is directed due north. However, the electron continues moving vertically upward undeflected. What would cause the Earth's magnetic field to have no effect on the path of this electron?

(A) There is an electric field directed due west (B) There is an electric field directed due east

(C) There is an electric field directed due south (D) There is an electric field directed vertically downward.

8. The image below is a set of subatomic particle tracks from a bubble chamber. In the center of the image is a spiraling particle. Assuming the spiral shape begins with motion up the page and the magnetic field of the bubble chamber is directed perpendicularly into the page, which of the following particles could this represent? *NOTE: Particles "spiral" in smaller and smaller radii due to losing energy while traveling through the liquid in the chamber. The tightening of the spiral has nothing to do with this question.*

(A) Proton
(B) Neutron
(C) Electron
(D) Photon



9. A single alpha particle, essentially a Helium nucleus, ${}^4_2He$, is traveling *undeflected* through a region where both an electric field and magnetic field exist. The electric field strength is $12\ {}^{N}\!/\!{}_{C}$ and the magnetic field strength is $3T$. What is the speed of the alpha particle?

(A) 0.25 m/s (B) 1.5 m/s (C) 4.0 m/s (D) 36 m/s

10. The current world's record (recognized by Guinness Book of World Records) magnetic field strength is 45-*T* for a continuous field magnet (*"Mag Lab World Records". National High Magnetic Field Laboratory, FL USA. 2008.*). The magnetic field strength of the Earth is a mere $32\mu T$, $32x10^{-6}T$. If a proton is injected at the same initial speed aimed perpendicularly at both magnetic fields in two separate experiments, what is the ratio of the diameter of the curved path resulting in the Earth field to the diameter of the curved path resulting in the huge field, $\frac{D_{Earth}}{D_{Huge}}$?

(A) $1.4x10^{-9}$ (B) $7x10^{-9}$ (C) $1.4x10^{9}$ (D) $7x10^{9}$

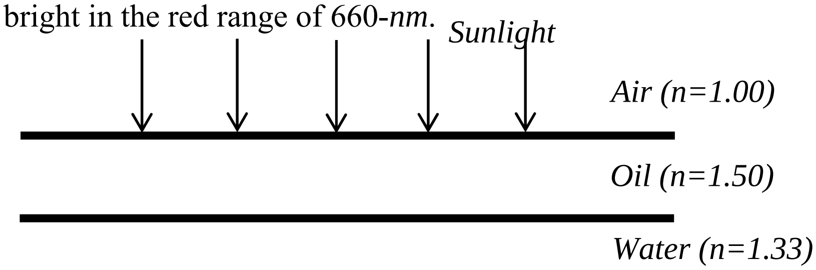
11. During a Young's double slit demonstration, your teacher shines two light sources, cleverly called ***A*** & ***B***, through a diffraction grating. It is noticed that light source ***A*** has a first order maximum at the same position as the second order maximum from source ***B***. If source ***A*** is a red laser beam of wavelength 700-*nm*, what is the wavelength of source ***B***?
(A) 1400-nm (B) 700-nm (C) 350-nm (D) 175-nm

Use the following information for Questions #12 & 13: An object is placed in front of a thin double convex lens of focal length *f*. The object is located at a distance of $^{2f}\!/_{3}$ to the left of the lens.

12. Which set of characteristics below correctly describes the image formed?
(A) Real, inverted, and smaller than the object (B) Real, upright, and larger than the object
(C) Virtual, upright, and smaller than the object (D) Virtual, upright, and larger than the object

13. Where is the image formed?
(A) $2f$ to the left of lens (B) $2f$ to the right of lens
(C) $^{f}\!/_{2}$ to the left of lens (D) $^{f}\!/_{2}$ to the right of lens

Use the following information for Questions #14 - 16: As imaged below, sunlight of many wavelengths is perpendicularly incident upon an oily film on water after a rainy day. A physics student observes that the oily film looks particularly bright in the red range of 660-*nm*.

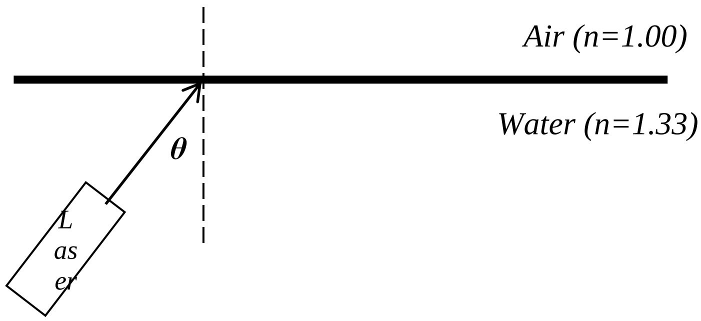


14. At which interface(s) is/are the incident waves inverted upon reflection?
(A) Air-oil only (B) Oil-water only (C) Both air-oil & oil-water (D) None

15. What is the minimum thickness of the oil film in order for the student to observe maximum brightness in the 660-*nm* light?
(A) 110-*nm* (B) 220-*nm* (C) 330-*nm* (D) 440-*nm*

16. During a classroom simulation of the oily film observation above, a soap film with index of refraction ***n*** = 1.20 is used instead of the oil. If this same 660-nm light is observed by the student again, what is the minimum thickness of the soap film used?
(A) 110-*nm* (B) 225-*nm* (C) 550-*nm* (D) 660-*nm*

Use the following information for Questions #17 - 19: As diagrammed below, a waterproof green laser of λ = 532-nm (as measured in air) is used under water to demonstrate a few optical phenomena. A volunteer student dives to the bottom of the deep end of a clear swimming pool and aims the laser light upward toward the surface.

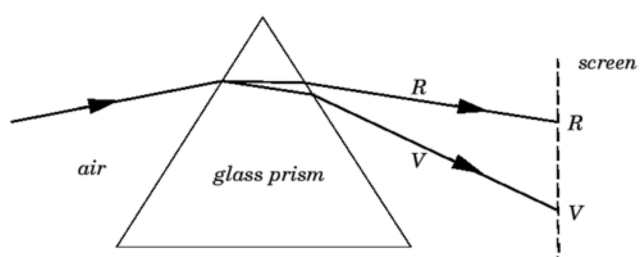


17. What minimum angle with the vertical, labelled as θ in the diagram above, would be the critical angle at that interface?
(A) 19° (B) 29° (C) 39° (D) 49°

18. What is the wavelength of the green laser light in the water?
(A) 200-*nm* (B) 400-*nm* (C) 532-*nm* (D) 708-*nm*

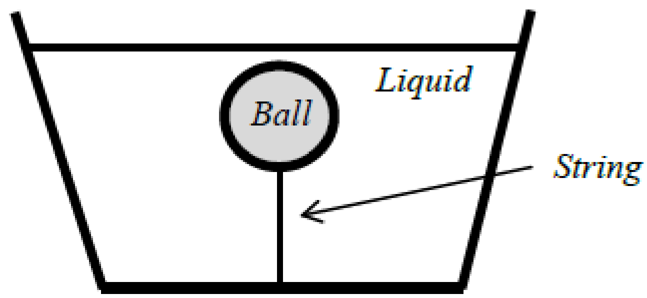
19. What is the apparent speed of the green laser light while in the water?
(A) $1.12x10^8\ {}^{m}/_{s}$ (B) $1.5x10^8\ {}^{m}/_{s}$ (C) $2.25x10^8\ {}^{m}/_{s}$ (D) $3x10^8\ {}^{m}/_{s}$

20. The world's third highest-selling music album of all time is Pink Floyd's *Dark Side of the Moon (1973)*; just behind AC/DC's *Back in Black (1980)* and Michael Jackson's *Thriller (1982)*. The front cover of that album shows white light shining upon and exiting a glass prism similar to the one shown below, albeit it in black & white and copyright free. The "***R***" and the "***V***" in the diagram represent "*Red*" and "*Violet*" respectively.



Why is the violet end of the spectrum bent at a higher angle through the glass prism than is the red end?
(A) Violet photons "slow down" more than red ones while passing through glass.
(B) Red photons "slow down" more than violet ones while passing through glass.
(C) The index of refraction of glass for red light is higher than that for violet light.
(D) The frequency of violet light decreases by a larger proportional amount than does the frequency of red.

21. As diagrammed below, a hollow rubber ball is fully submerged in a liquid and held in place by a string attached to the ball at one end and the bottom of the container at the other. If the mass of the ball is 0.5-kg and the tension in the string is 8-*N*, what is the buoyant force acting on the ball?

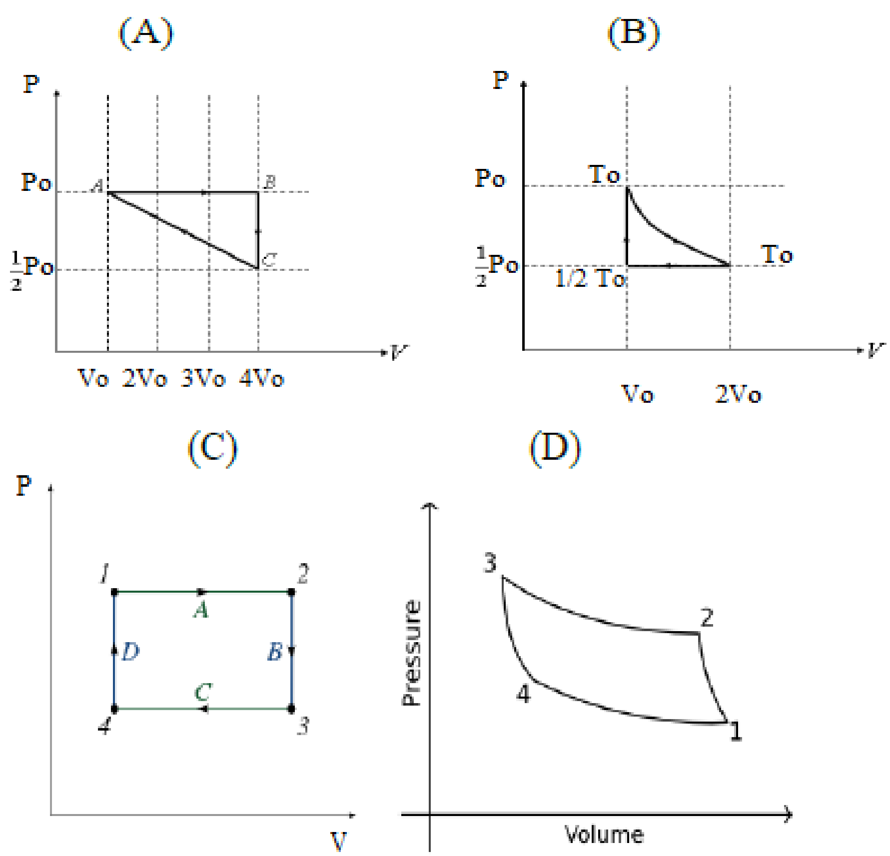


(A) 3-*N* (B) 5-*N* (C) 8-*N* (D) 13-*N*

22. During each cycle of an ideal *Carnot* engine, it absorbs 800 *kJ* of heat from the environment at 1600 *K* and gets rid of 500 *kJ* of heat to the low temperature reservoir. Which of the following is the approximate temperature of the low temperature reservoir?

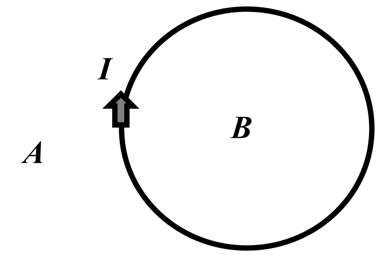
(A) 250 *K* (B) 500 *K* (C) 750 *K* (D) 1000 *K*

23. Each of the following four PV diagrams is taken from different free online sources and each has independent scaling that has nothing to do with the others. Which diagram best represents an ideal Carnot cycle showing *only* adiabatic and/or isothermal processes?

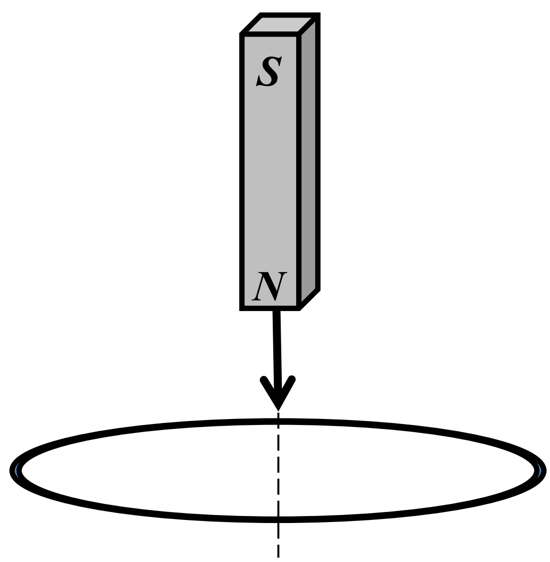


24. A circular loop of wire has a clockwise current as shown below. In what direction is the magnetic field this current causes as seen from point A outside the loop and from point B inside the loop?

	Point A	***Point B***
(A)	Into the paper	Into the paper
(B)	Into the paper	Out of the paper
(C)	Out of the paper	Out of the paper
(D)	Out of the paper	Into the paper



25. A permanent bar magnet is dropped vertically from rest above a stationary horizontal conducting loop of wire. The magnet falls without rotating through the loop of wire. The north pole of the bar magnet points downward towards the bottom of the page as it falls. Which statement provided is correct?



(A) The induced current in the loop always flows clockwise as seen from above.
(B) The induced current in the loop always flows counterclockwise as seen from above.
(C) The induced current in the loop first flows counterclockwise and then flows clockwise as seen from above.
(D) The induced current in the loop first flows clockwise and then flows counterclockwise as seen from above.

AP I and AP 2 PHYSICS FORMULAE Updated 12-23-2015

Constants & Conversion Factors

Proton and Neutron Mass	$m_p = 1.67x10^{-27} kg$	Fundamental charge	$e = 1.6x10^{-19} C$
Electron Mass	$m_e = 9.11x10^{-31} kg$	Electron Volt	$1eV = 1.6x10^{-19} J$
Avogadro's #	$6.02x10^{23} mol^{-1}$	Universal Gravitational constant	$G = 6.67x10^{-11} Nm^2/kg^2$
Universal gas constant	$R = 8.31 J/mol \cdot K$	Speed of Light	$c = 3.00x10^8 m/s$
Boltzmann's constant	$k_B = 1.38x10^{-23} J/K$	Magnetic constant	$k' = 1x10^{-7} T \cdot m/A$
1 unified atomic mass unit		$1u = 1.66x10^{-27} kg = 931 MeV/c^2$	
Planck's Constant		$h = 6.63x10^{-34} J \cdot s = 4.14x10^{-15} eV \cdot s$ $hc = 1.99x10^{-25} J \cdot m = 1240 eV \cdot nm$	
Coulomb's Law constant		$k = \frac{1}{4\pi\varepsilon_o} = 9.0x10^9 N \cdot m^2/kg^2$ $\varepsilon_o = 8.85x10^{-12} C^2/N \cdot m^2$	

MECHANICS

$\bar{v} = \frac{\Delta x}{\Delta t}$

$\bar{a} = \frac{\Delta v}{\Delta t}$

$v_f = v_i + at$

$\Delta x = v_i t + \frac{1}{2}at^2$

$2a\Delta x = v_f^2 - v_i^2$

$\Sigma F = ma$

$W = mg$

$F_g = G\frac{m_1 m_2}{r^2}$

$U_g = G\frac{m_1 m_2}{r}$

$\rho = mv$

$F\Delta t = m\Delta v$

$\mu = \frac{F_f}{F_N}$

Δx = displacement (change of position)

$\bar{v}$ = average velocity

$\bar{a}$ = average acceleration

v_i = initial velocity

v_f = final velocity

F = force

F_f = force of friction

F_N = normal force

F_g = gravitational force

G = Universal Gravitational Constant

ρ = momentum

μ = coefficient of friction

r = distance between center of masses

W = weight

m = mass

U_g = gravitational PE

ELECTRICITY

$F_e = k\frac{q_1 q_2}{r^2}$

$E = \frac{F}{q}$

$\Delta U_E = q\Delta V$

$V = \frac{W}{q} = Ed$

$I = \frac{\Delta q}{\Delta t}$

$V = IR$

$P = VI = I^2 R = \frac{V^2}{R}$

SERIES CIRCUIT

$I_T = I_1 = I_2 = I_3 = ...$

$V_T = V_1 + V_2 + V_3 + ...$

$R_T = R_1 + R_2 + R_3 + ...$

PARALLEL CIRCUITS

$I_T = I_1 + I_2 + I_3 + ...$

$V_T = V_1 = V_2 = V_3 = ...$

$R_T = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + ...}$

C = Capacitance

E = electric field intensity

I = electric current

k = electrostatic constant

P = Power

q = charge

R = resistance

U_E = electric potential Energy

U_C = energy stored in capacitor

V = electric potential difference

W = Work

$C = Q/\Delta V$

$U_C = \frac{1}{2}Q\Delta V = \frac{1}{2}C\Delta V^2$

$C_{parallel} = \Sigma C_i$

$C_{series} = \frac{1}{\Sigma\left(\frac{1}{C_i}\right)}$

ENERGY AND WORK

$W = F\Delta x \cos\theta$

$P = \frac{W}{\Delta t} = \frac{\Delta E}{\Delta t} = Fv$

$PE_g = mgh$

$KE = \frac{1}{2}mv^2$

$F = -kx$

$PE_s = \frac{1}{2}kx^2$

h = height

k = spring constant

KE = kinetic energy

PE_g = gravitational potential energy

PE_s = potential energy stored in a spring

P = power

W = work

x = change in spring length from the equilibrium position

CIRCULAR MOTION & ROTATION

$a_c = \frac{v^2}{r}$

$F_c = m\frac{v^2}{r}$

$1rev = 2\pi rad = 360°$

$\tau = Fxr = I\alpha$

$I = \Sigma mr^2$

$L = I\omega$

$K_{rot} = \frac{1}{2}I\omega^2$

$x = A\cos(\omega t)$

$x = A\cos(2\pi ft)$

a_c = centripetal acceleration

F_c = centripetal force

τ = Torque

I = Rotational Inertia

α = Angular acceleration

ω = Angular velocity

K_{rot} = Rotational KE

x = position

HEAT AND THERMODYNAMICS

$Q = mc\Delta T$

$Q = mL_f$

$Q = mL_V$

$\Delta L = \alpha L_o \Delta T$

$\frac{Q}{\Delta t} = \frac{kA\Delta T}{L}$

$PV = nRT = NkT$

$K = \frac{3}{2}k_B T$

$\Delta U = \frac{3}{2}nR\Delta T$

$W = -P\Delta V$

$\Delta U = Q + W$

c = specific heat
L_f = latent heat of fusion
L_V = latent heat of vaporization
Q = amount of heat
ΔT = change in temperature
α = coefficient of linear expansion
L_o = original length
$c_{water} = 4186\frac{J}{kg°K}$
K = kinetic energy
L = thickness
U = internal energy
W = work done on a system

WAVE PHENOMENA & SHM

$T = \frac{1}{f}$

$v = f\lambda$ OR $= \nu\lambda$

$n = \frac{c}{v}$

$n_i \sin\theta_i = n_r \sin\theta_r$

$\lambda = \frac{xd}{L}$

$\sin\theta_c = \frac{1}{n}$

$T_S = 2\pi\sqrt{\frac{m}{k}}$

$T_P = 2\pi\sqrt{\frac{L}{g}}$

c = speed of light in a vacuum
d = distance between slits
$f = \nu$ = frequency
L = distance from slit to screen
n = index of absolute refraction
T = period
v = speed
x = distance from central maximum to first-order maximum
λ = wavelength
θ = angle
θ_c = critical angle relative to air

GEOMETRIC OPTICS & SOUND

$\frac{1}{f} = \frac{1}{d_i} + \frac{1}{d_o}$

$\frac{h_i}{h_o} = \frac{d_i}{d_o}$

$\beta = 10\log\frac{I}{I_o}$

f = focal length
d_i = image distance
d_o = object distance
h_o = object size
h_i = image size
β = Sound level
I = Sound Intensity
I_o = Threshold Intensity

ELECTROMAGNETIC APPLICATIONS

$F_M = Bqv$

$F_M = BIL$

$\varepsilon = BLv$

$\frac{N_P}{N_S} = \frac{V_P}{V_S}$

$V_P I_P = V_S I_S$ (ideal)

$efficiency = \frac{V_S I_S}{V_P I_P}$

$\phi_B = B \cdot A$

$\Delta\phi_B = \varepsilon t$

B = magnetic field strength
I_P = current in primary
I_S = current in secondary
N_P = number of turns in primary coil
N_S = number of turns in secondary coil
V_P = voltage of primary
V_S = voltage of secondary
L = length of conductor
V = electric potential difference
v = speed of particle

FLUID MECHANICS

$\rho = \frac{m}{V}$

$P = \frac{F}{A}$

$P = P_o + mgh$

$F_b = \rho V g$

$A_1 v_1 = A_2 v_2$

$P_1 + \rho g y_1 + \frac{1}{2}\rho v_1^2 =$

$= P_2 + \rho g y_2 + \frac{1}{2}\rho v_2^2$

A = Area
F = force
h = depth
P = pressure
V = volume
v = speed
y = height
ρ = density

MODERN PHYSICS

$E = hf$

$K_{max} = hf - \phi$

$\lambda = \frac{h}{p}$

$E = mc^2$

E = energy
f = frequency
K = kinetic energy
m = mass
p = momentum
λ = wavelength
ϕ = work function

AP PHYSICS II Golden Rod

MARCH 10, 2016

SOLUTIONS

Record on the area record the % correct (Corrections)

1. B	14. A
2. C	15. A
3. B	16. B All full credit ans 275
4. C	17. D
5. A	18. B
6. D	19. C
7. B	20. A
8. C	21. D
9. C	22. D
10. C All full credit 1.4×10^6.	23. D
11. C	24. D
12. D	25. C
13. A	

PHYSICS II: for all students currently enrolled in AP physics II. 25 multiple choice questions per exam.

January: Heat & Thermodynamics, Fluid Statics and Dynamics

February: Electrostatics: electric force, fields, & potential, DC Circuits and RC Circuits, plus January Topics

March: Magnetics and Electromagnetic induction, Geometric & Physical optics, plus Jan and Feb Topics

April: Quantum physics, atomic and nuclear physics, plus Jan, Feb and March topics.

Dates for 2016 Season

Thursday March 10, 2016 Thursday April 14, 2016

New Jersey Science League

*All areas and schools must complete the April exam and mail in the results by April 28th, 2016.

PO Box 65 Stewartsville, NJ 08886-0065

phone # 908-213-8923 fax # 908-213-9391 email newjsl@ptd.net **Web address:**
www:entnet.com/~personal/njscil/html

PLEASE RETURN THE AREA RECORD AND ALL TEAM MEMBER SCANTRONS(ALL STUDENTS PLACING 1ST, 2ND, 3RD, AND 4TH).

If you return scantrons of alternates, then label them as ALTERNATES.

Dates for 2017 Season

Thursday January 12, 2017 Thursday February 9, 2017

Thursday March 9, 2017 Thursday April 13, 2017

AP PHYSICS II Golden Rod

APRIL 14, 2016

Directions: For each question or statement fill in the appropriate space on the answer sheet. Use the letter preceding the word, phrase, or quantity which best completes or answers the question. Each of the 25 questions is worth 4 points. *Use: $g = 10.\ m/s^2$*. As prescribed by the College Board for AP Physics, the work done *on* a system is a *positive* quantity.

1. Consider the following three properties as a light source shines on a metal surface.

   I. The intensity of the light.

   II. The wavelength of the light.

   III. The ionization energy of the atoms that make up the metal.

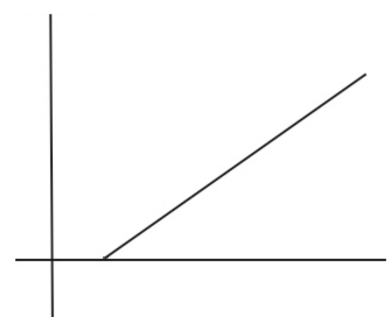
Which of these determines the maximum kinetic energy of ejected photoelectrons?

(A) I only (B) II only (C) I & III only (D) II & III only

2. During a Lab, you compare properties of two light sources. One source is visible monochromatic blue laser light of wavelength, λ_{Blue}, 400-nm and the other is an infrared source of wavelength, λ_{IR}, 800-nm. What is the ratio of the momentum of a photon of visible blue light to that of the infrared, p_{Blue}/p_{IR}?

(A) 4 (B) 2 (C) $1/2$ (D) $1/4$

Use the following information for Questions #3 – 5: The sketch below represents a typical graph of photoelectric effect data from a class Lab activity. The vertical axis represents the stopping potential in *Volts* for the ejected photoelectrons and the horizontal axis represents the frequency of the incident light in *Hz*.



3. The slope of this straight line represents

(A) h/e (B) Work Function

(C) Planck's Constant (D) Threshold Frequency

4. The *x*-intercept of this straight line represents

(A) h/e (B) Work Function

(C) Planck's Constant (D) Threshold Frequency

5. The *y*-intercept of this straight line can be used to calculate

(A) h/e (B) Work Function

(C) Planck's Constant (D) Threshold Frequency

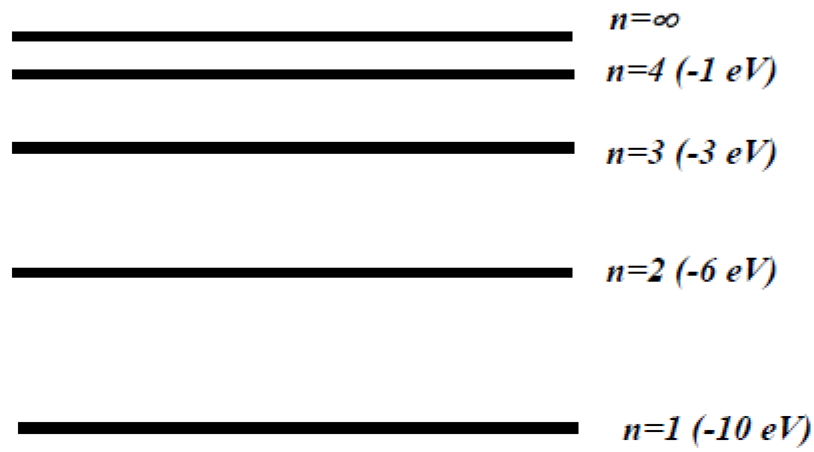
6. An X-Ray machine generates 50 *KeV* photons. What is the **wavelength** of these photons?

(A) $2.5x10^{-12}m$ (B) $2.5x10^{-11}m$ (C) $2.5x10^{-10}m$ (D) $2.5x10^{-9}m$

7. What is the de Broglie wavelength of an electron that has been accelerated through a potential difference of 200 V?

(A) $8.7x10^{-11}m$ (B) $8.7x10^{-6}m$ (C) $5.4x10^{-6}m$ (D) $5.4x10^{8}m$

Use the following information for Questions #8 – 10: Below represents the electron levels of a hypothetical atom. The drawing is not drawn to scale.



8. Which of the following electron transitions would result in the emission of a photon with the **largest** wavelength?

(A) $n=2 \rightarrow n=1$ (B) $n=3 \rightarrow n=2$ (C) $n=4 \rightarrow n=3$ (D) $n=4 \rightarrow n=1$

9. How many different photons could be emitted if several ground state electrons were "bumped" up to $n=4$?

(A) 1 (B) 3 (C) 4 (D) 6

10. What is the wavelength associated with an incident photon that causes a ground state electron to jump to $n=3$?

(A) 124 *nm* (B) 177 *nm* (C) 207 *nm* (D) 413 *nm*

11. You are performing a Lab where you examine an unknown radioactive substance designated by ${}^{A}_{Z}XX$, where ***A*** is the atomic mass, ***Z*** is the atomic number, and ***XX*** is the general element symbol of the initial substance. Later, you note this substance has changed into ${}^{A-4}_{Z-1}ZZ$ after undergoing two separate radioactive decay processes. Which of the following is a viable pair of two stages that would result in changing ${}^{A}_{Z}XX$ into ${}^{A-4}_{Z-1}ZZ$? Alpha, beta, and gamma decays are designated as α, β, and γ, respectively.

	1st Decay	***2nd Decay***
(A)	β^- emission	α emission
(B)	β^- emission	γ emission
(C)	β^- emission	β^- emission
(D)	α emission	γ emission

12. The first several steps in the natural decay series of ${}^{238}_{92}U$ are, in order, one alpha decay followed by 2 beta decays and then three more alpha decays. What is the result of these six decays?

(A) ${}^{230}_{90}Th$ (B) ${}^{226}_{88}Ra$ (C) ${}^{222}_{86}Rn$ (D) ${}^{218}_{84}Po$

13. A nucleus of Cesium, ${}^{157}_{55}Cs$, emits one gamma photon and becomes

(A) ${}^{156}_{55}Cs$ (B) ${}^{157}_{56}Ba$ (C) ${}^{153}_{53}I$ (D) ${}^{157}_{55}Cs$

14. Given the mass of a proton is $1.007825u$ and the mass of a neutron is $1.008665u$, what is the "binding energy of an oxygen nucleus, ${}^{16}_{8}O$, of mass $15.999401u$?

(A) $0.6MeV$ (B) $1.2MeV$ (C) $60MeV$ (D) $123MeV$

15. Very rarely, certain elements will decay via emitting a positron. If Scandium, ${}^{44}_{21}Sc$, decays by emitting this positron, the resulting nuclide would be

(A) ${}^{44}_{22}Ti$ (B) ${}^{43}_{21}Sc$ (C) ${}^{43}_{20}Ca$ (D) ${}^{44}_{20}Ca$

16. Verizon™ uses radio waves of frequency 750 MHz for their cellular 4G technology. What are the energy and momentum associated with these Verizon™ photons?

	Photon Energy	***Photon Momentum***
(A)	$3\mu eV$	$1.7x10^{-33}\ kg \cdot m/s$
(B)	$3\mu eV$	$0.6x10^{-33}\ kg \cdot m/s$
(C)	$5\mu eV$	$1.7x10^{-33}\ kg \cdot m/s$
(D)	$5\mu eV$	$0.6x10^{-33}\ kg \cdot m/s$

17. For another boring physics Lab activity, you are provided 6000 nuclei of an isotope of Barium, ${}^{144}_{56}Ba$, used in medical diagnostics. Exactly 2 minutes later, 5995 Barium nuclei have decayed into something less harmful. From this information, approximately what is the half-life of this Barium isotope?

(A) 10 seconds (B) 12 seconds (C) 14 seconds (D) 16 seconds

18. In a typical ${}^{238}_{92}U$ decay, ${}^{238}_{92}U \rightarrow {}^{234}_{90}Th + {}^{4}_{2}He$, which of the following statements is correct about the final products assuming the ${}^{238}_{92}U$ nucleus is considered to be at rest before the decay process?

(A) They have equal kinetic energy, but the ${}^{4}_{2}He$ has more momentum.

(B) They have equal momenta magnitude and equal kinetic energies.

(C) They have equal kinetic energies, but the Thorium nucleus has more momentum.

(D) They have equal momenta magnitude, but the ${}^{4}_{2}He$ has greater kinetic energy.

19. Which one of the following physics quantities is *not necessarily* conserved during nuclear processes?

(A) Atomic number (B) Number of nucleons (C) Electric charge (D) total mass plus energy

20. Current nuclear power plants use fission of 4% pure ${}^{235}_{92}U$. Each decaying nuclide releases a total of 200 MeV of energy. What is the rate at which ${}^{235}_{92}U$ must be "used" in order to supply the typical 1000 MW associated with a power plant? The mass of one ${}^{235}_{92}U$ nucleus is $235.0439u$.

(A) $3.125x10^{19}\ kg/s$ (B) $4x10^{-25}\ kg/s$ (C) $1.2x10^{-5}\ kg/s$ (D) $1.6x10^{-19}\ kg/s$

21. An oversimplified view of nuclear fusion is throwing two heavy Hydrogen nuclei called deuterons together to make one Helium nucleus, ${}_{1}^{2}H + {}_{1}^{2}H \rightarrow {}_{2}^{4}He$. How much energy is released in one of these reactions? Use the following information. Mass of ${}_{1}^{2}H = 2.014102u$ and mass of ${}_{2}^{4}He = 4.002603u$.

(A) 0.24 MeV (B) 2.4 MeV (C) 24 MeV (D) 240 MeV

22. You are probably familiar with the medical acronyms *CAT*-scan (Computerized Axial Tomography) and *PET*-scan (Positron Emission Tomography). The *CAT*-scan is simply a computerized X-Ray enhancement whereas the *PET*-scan takes advantage of matter/anti-matter production. The positron, essentially a positively charged electron with the same mass as a "regular" electron, is annihilated in a head-on collision with a regular electron traveling at the same speed. When these two matter-antimatter partners annihilate into pure energy, a pair of high-energy gamma rays are created. What is the angle between the emitted gamma rays created this way?

(A) Zero degrees (B) 90^{o} (C) 180^{o}

(D) All angles are possible. It depends on the spin of the positron-electron pair

23. You are provided four equal resistors, R, to connect across a constant voltage source. Here are the directions: "*Two resistors are connected in series. This series combination is then connected in parallel to a 3rd resistor. Then, this group of three resistors is connected in series to the 4th resistor.*" What is the equivalent resistance of your configuration of four resistors?

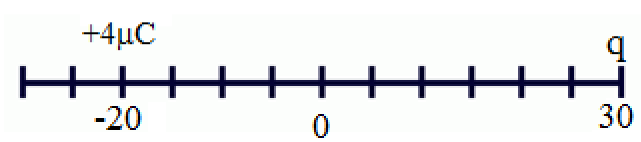
(A) $\frac{5R}{2}$ (B) $\frac{5R}{3}$ (C) $\frac{3R}{5}$ (D) $\frac{2R}{5}$

24. In an old TV picture tube, NOT flat screen modern ones, an electron is shot from a hot surface through a large potential difference of 10,000 V. What speed does one electron reach?

(A) $6x10^{7}\, m/s$ (B) $6x10^{6}\, m/s$ (C) $7x10^{7}\, m/s$ (D) $7x10^{6}\, m/s$

25. The accompanying diagram shows a positive charge of 4-μC is placed 20-cm to the left of the origin on a number line. Meanwhile, another charge of unknown magnitude and polarity, q, is placed 30-cm to the right of the origin. If the net electric potential is zero at the origin, what is q? Assume electric potential is zero at infinity.

(A) $-9\mu C$ (B) $-6\mu C$ (C) $+6\mu C$ (D) $+9\mu C$



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$\Sigma F = ma$

$W = mg$

$F_g = G\frac{m_1 m_2}{r^2}$

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$\rho = mv$

$F\Delta t = m\Delta v$

$\mu = \frac{F_f}{F_N}$

Δx = displacement (change of position)

$\bar{v}$ = average velocity

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v_i = initial velocity

v_f = final velocity

F = force

F_f = force of friction

F_N = normal force

F_g = gravitational force

G = Universal Gravitational Constant

ρ = momentum

μ = coefficient of friction

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W = weight

m = mass

U_g = gravitational PE

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$I = \frac{\Delta q}{\Delta t}$

$V = IR$

$P = VI = I^2R = \frac{V^2}{R}$

SERIES CIRCUIT

$I_T = I_1 = I_2 = I_3 = ...$

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$R_T = R_1 + R_2 + R_3 + ...$

PARALLEL CIRCUITS

$I_T = I_1 + I_2 + I_3 + ...$

$V_T = V_1 = V_2 = V_3 = ...$

$R_T = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + ...}$

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P = Power

q = charge

R = resistance

U_E = electric potential Energy

U_C = energy stored in capacitor

V = electric potential difference

W = Work

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$U_C = \frac{1}{2}Q\Delta V = \frac{1}{2}C\Delta V^2$

$C_{parallel} = \Sigma C_i$

$C_{series} = \frac{1}{\Sigma\left(\frac{1}{C_i}\right)}$

ENERGY AND WORK

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$I = \Sigma mr^2$

$L = I\omega$

$K_{rot} = \frac{1}{2}I\omega^2$

$x = A\cos(\omega t)$

$x = A\cos(2\pi ft)$

a_c = centripetal acceleration

F_c = centripetal force

τ = Torque

I = Rotational Inertia

α = Angular acceleration

ω = Angular velocity

K_{rot} = Rotational KE

x = position

HEAT AND THERMODYNAMICS

$Q = mc\Delta T$

$Q = mL_f$

$Q = mL_V$

$\Delta L = \alpha L_o \Delta T$

$\frac{Q}{\Delta t} = \frac{kA\Delta T}{L}$

$PV = nRT = NkT$

$K = \frac{3}{2}k_B T$

$\Delta U = \frac{3}{2}nR\Delta T$

$W = -P\Delta V$

$\Delta U = Q + W$

c = specific heat
L_f = latent heat of fusion
L_V = latent heat of vaporization
Q = amount of heat
ΔT = change in temperature
α = coefficient of linear expansion
L_o = original length
$c_{water} = 4186\frac{J}{kg°K}$
K = kinetic energy
L = thickness
U = internal energy
W = work done on a system

WAVE PHENOMENA & SHM

$T = \frac{1}{f}$

$v = f\lambda$ OR $= \nu\lambda$

$n = \frac{c}{v}$

$n_i \sin\theta_i = n_r \sin\theta_r$

$\lambda = \frac{xd}{L}$

$\sin\theta_c = \frac{1}{n}$

$T_S = 2\pi\sqrt{\frac{m}{k}}$

$T_P = 2\pi\sqrt{\frac{L}{g}}$

c = speed of light in a vacuum
d = distance between slits
$f = \nu$ = frequency
L = distance from slit to screen
n = index of absolute refraction
T = period
v = speed
x = distance from central maximum to first-order maximum
λ = wavelength
θ = angle
θ_c = critical angle relative to air

GEOMETRIC OPTICS & SOUND

$\frac{1}{f} = \frac{1}{d_i} + \frac{1}{d_o}$

$\frac{h_i}{h_o} = \frac{d_i}{d_o}$

$\beta = 10\log\frac{I}{I_o}$

f = focal length
d_i = image distance
d_o = object distance
h_o = object size
h_i = image size
β = Sound level
I = Sound Intensity
I_o = Threshold Intensity

ELECTROMAGNETIC APPLICATIONS

$F_M = Bqv$

$F_M = BIL$

$\varepsilon = BLv$

$\frac{N_P}{N_S} = \frac{V_P}{V_S}$

$V_P I_P = V_S I_S$ (ideal)

$efficiency = \frac{V_S I_S}{V_P I_P}$

$\phi_B = B \cdot A$

$\Delta\phi_B = \varepsilon t$

B = magnetic field strength
I_P = current in primary
I_S = current in secondary
N_P = number of turns in primary coil
N_S = number of turns in secondary coil
V_P = voltage of primary
V_S = voltage of secondary
L = length of conductor
V = electric potential difference
v = speed of particle

FLUID MECHANICS

$\rho = \frac{m}{V}$

$P = \frac{F}{A}$

$P = P_o + mgh$

$F_b = \rho V g$

$A_1 v_1 = A_2 v_2$

$P_1 + \rho g y_1 + \frac{1}{2}\rho v_1^2 =$

$= P_2 + \rho g y_2 + \frac{1}{2}\rho v_2^2$

A = Area
F = force
h = depth
P = pressure
V = volume
v = speed
y = height
ρ = density

MODERN PHYSICS

$E = hf$

$K_{max} = hf - \phi$

$\lambda = \frac{h}{p}$

$E = mc^2$

E = energy
f = frequency
K = kinetic energy
m = mass
p = momentum
λ = wavelength
ϕ = work function

AP PHYSICS II **Golden Rod**

APRIL 14, 2016

SOLUTIONS (No Corrections)

1. D	14. D
2. B	15. D
3. A	16. A
4. D	17. B
5. B	18. D
6. B	19. A
7. A	20. C
8. C	21. C
9. D	22. C
10. B	23. B
11. A	24. A
12. C	25. B
13. D	

PHYSICS II: for all students currently enrolled in AP physics II. 25 multiple choice questions per exam.

January: Heat & Thermodynamics, Fluid Statics and Dynamics

February: Electrostatics: electric force, fields, & potential, DC Circuits and RC Circuits, plus January Topics

March: Magnetics and Electromagnetic induction, Geometric & Physical optics, plus Jan and Feb Topics

April: Quantum physics, atomic and nuclear physics, plus Jan, Feb and March topics.

Dates for 2016 Season

Thursday April 14, 2016

New Jersey Science League

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PLEASE RETURN THE AREA RECORD AND ALL TEAM MEMBER SCANTRONS(ALL STUDENTS PLACING 1ST, 2ND, 3RD, AND 4TH).

If you return scantrons of alternates, then label them as ALTERNATES.

Dates for 2017 Season

Thursday January 12, 2017 Thursday February 9, 2017

Thursday March 9, 2017 Thursday April 13, 2017