PHYSICS II Golden Rod No Corrections

JANUARY, 2018

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;** $\Delta U = Q + W$

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

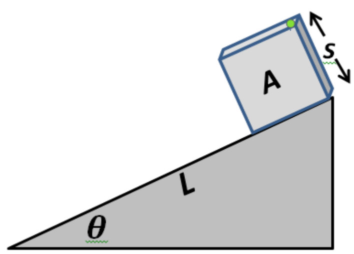
$c_{Copper} = 387\ J/kg\cdot K$, $c_{Aluminum} = 900\ J/kg\cdot K$, $c_{Mercury} = 140\ J/kg\cdot K$, & $c_{Air} = 1006\ J/kg\cdot K$

$\rho_{water} = 1000\ kg/m^3$, $\rho_{ice} = 971\ kg/m^3$, $\rho_{steam} = 0.600\ kg/m^3$, $P_{Atmosphere} = 1x10^5\ Pa$

1. Interstellar space is not as empty as you are lead to believe. With an approximate density of $2.5x10^{-27}\ kg/m^3$, it is close to "nothing", but not quite. What volume of water, $\rho = 1000\ kg/m^3$, has the same mass as $9x10^{24}\ m^3$ of interstellar space.

(A) $2.25m^3$ (B) $0.0225m^3$ (C) $2.25x10^{-3}m^3$ (D) $2.25x10^{-5}m^3$

2. As shown below, a cube of *Adamantium*, the "metal" that makes Marvel's *Wolverine* so tough, of density ρ and sides ***s***, rests on an incline at angle θ. What is the pressure the block of *Adamantium* exerts on the incline in addition to the ever-present atmospheric pressure?



(A) $\frac{\rho V g}{s^2}$ (B) $\frac{\rho V g \cos\theta}{s^2}$ (C) $\frac{\rho V g \sin\theta}{s^2}$ (D) $\frac{\rho V g \tan\theta}{s^2}$

Use the following information for Questions #3 - #5. A rectangular in-ground swimming pool measures 15*m* x 10*m* x 3*m*, *length* x *width* x *depth*.

3. If filled to the top, what is the weight of the water in *Newtons*?

(A) $450N$ (B) $4.5x10^3N$ (C) $4.5x10^6N$ (D) $4.5x10^9N$

4. What is the gauge pressure measured at the bottom of the pool?

(A) $300Pa$ (B) $3x10^4Pa$ (C) $1.3x10^3Pa$ (D) $1.3x10^5Pa$

5. What is the absolute pressure measured at the bottom of the pool?

(A) $300Pa$ (B) $3x10^4Pa$ (C) $1.3x10^3Pa$ (D) $1.3x10^5Pa$

6. The water supply to a typical house uses a $\frac{3}{4}$" $(1.90cm)$ diameter horizontal copper pipe. Upon entering the house, the pipe decreases in size to $\frac{1}{2}$" $(1.27cm)$ diameter, also horizontally aligned. The speed of the water in the larger supply pipe is $2\,m/s$. What is the speed of the water once it passes into the smaller pipe?

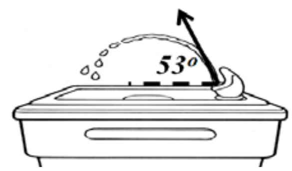
(A) $9\,m/s$ (B) $6\,m/s$ (C) $4.5\,m/s$ (D) $3\,m/s$

7. A typical garden hose will increase water flow from $2\,m/s$ to $25\,m/s$ by constricting the flow with a smaller tube. Calculate the pressure inside the garden hose given that the absolute pressure in the nozzle is 1atm. Assume level frictionless flow throughout.

(A) $1x10^5\,Pa$ (B) $2x10^5\,Pa$ (C) $3.1x10^5\,Pa$ (D) $4.1x10^5\,Pa$

8. Outside your physics lab is a water fountain. It is fed by a $\frac{1}{2}$" $(1.27cm)$ supply pipe that is decreased in diameter to $\frac{3}{8}$" $(0.95cm)$ at the end nozzle. If the water in the supply pipe travels at $3\,m/s$ and the fountain nozzle is aimed at an angle of 53^o above the horizontal as shown below, how far horizontally does an unimpeded stream of water travel? Use $\sin 53^o = 0.8$ and $\cos 53^o = 0.6$.

(A) $0.8m$ (B) $1.6m$ (C) $2.8m$ (D) $3.2m$



9. Volumes of matter change quantity during heat differences just like linear dimensions. Volume differences follow basically the same mathematical relationship as linear changes: $\Delta V = \beta V \Delta T$ where ΔV is the change in volume, β is a simple coefficient, V is the original volume, and ΔT is the change in temperature.

With this in mind, why is it not a good idea to "top off" your car gas tank during hot summer months? "Topping off" is the practice of forcing just a little more gasoline into your tank after the automatic nozzle has shut off. This practice will literally *fill* your steel gas tank and the filler neck leading up to the gas cap with gasoline, leaving no room for air. The coefficients of volume expansion for steel and gasoline are $\beta_{Steel} = 3.5x10^{-5}\,\frac{1}{^oC}$ and $\beta_{Gasoline} = 9.5x10^{-4}\,\frac{1}{^oC}$, respectively.

(A) The cooler gasoline coming up from the cool underground tank immediately cools and contracts the steel gas tank. As the steel and cool gas absorb heat from the surrounding air, both will expand, but the gasoline expands much *more* than the steel tank and can cause the tank to overflow from the gas cap area.

(B) The cooler gasoline coming up from the cool underground tank immediately cools and contracts the steel gas tank. As the steel and cool gas absorb heat from the surrounding air, both will expand, but the gasoline expands much *less* than the steel tank and this can cause a large air pocket within the tank that can disrupt gasoline flow to the engine.

(C) Under the same temperature difference, both the gasoline and gas tank will expand or contract by the exact same amount. This means, on a warm day, your gas tank would be *larger* than your gas gauge states making the gauge inaccurate.

(D) Under the same temperature difference, both the gasoline and gas tank will expand or contract by the exact same amount. This means, on a warm day, your gas tank would be *smaller* than your gas gauge states making the gauge inaccurate.

Use the following information for Questions #10 - #12. Suppose you go for a bicycle ride on a cool 18^oC morning. When you leave your house, the tires are fully inflated at an absolute pressure of $7.2x10^5\,Pa$ representing the required gauge pressure of $90\,lb/in^2$ for the thin touring tires. By the end of your ride, the tire temperature has increased to 35^oC. Treat the air as an ideal gas.

10. What is the absolute pressure of your tires at the end of this ride? Assume no appreciable change in volume and no leaks.

(A) $7x10^5\,Pa$ (B) $7.5x10^5\,Pa$ (C) $1.5x10^6\,Pa$ (D) $7.5x10^6\,Pa$

11. How many moles of gas are in each tire mentioned above *when you leave your house* if the volume inside each tire is two liters $(2x10^{-3}m^3)$?

(A) 0.58 (B) 9.4 (C) 5.8 (D) 580

12. How many moles of gas are in each tire mentioned above *upon completing your trip* if the volume inside each tire is two liters $(2x10^{-3}m^3)$?

(A) 0.58 (B) 9.4 (C) 5.8 (D) 580

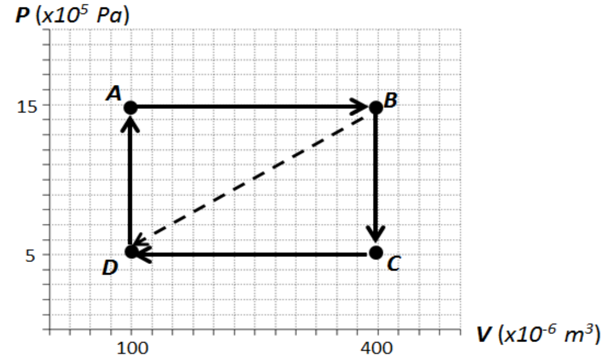
13. During Holiday dinner preparations, you pour 0.5 kg of 20^oC water into a pre-heated 0.75 kg aluminum pan at 150^oC. The pan is off the stove sitting on an insulated pad. Assume no splatter, no heat loss to the surrounding environment, and no appreciable water boils off. What is the final temperature of the water and pan system upon reaching thermal equilibrium? Use values provided in test header.

(A) 20^oC (B) 52^oC (C) 85^oC (D) 150^oC

14. During a particular exchange, 50-J of heat is transferred into a system while the system does 15-J of work. This is followed by a heat transfer of 30-J out of the system while 5-J of work is done on the system. What is the net change of internal energy of this sysem?

(A) $0J$ (B) $10J$ (C) $20J$ (D) $30J$

Use the following information for Questions #15 - #17. The graph below represents an ideal gas undergoing thermodynamic processes starting at state ***A***.



15. What is the net work done during one cycle ***A→B→C→D→A*** for the system depicted?

(A) $300J$ by the system (B) $300J$ on the system
(C) $450J$ by the system (D) $450J$ on the system

16. If a process took a short cut directly from state ***B*** to state ***D***, ***B→D***, along the straight path indicated by the dashed line, how much work is done during the process from state ***B*** to state ***D***?

(A) $150J$ by the system (B) $150J$ on the system
(C) $300J$ by the system (D) $300J$ on the system

17. If the temperature at state ***B*** is 1473^oC, what is the temperature at state ***D***?

(A) -128.5^oC (B) -145.5^oC (C) 418.5^oC (D) 1473^oC

18. If 4 moles of an ideal gas exerts a pressure of ***P*** when confined in a rigid container of $40m^3$ at 307^oC, what would the pressure be if you placed 200 moles of this gas in a larger rigid $100m^3$ container at 597^oC ?

(A) $0.6P$ (B) $0.8P$ (C) $30P$ (D) $39P$

19. If the average speed of molecules in a sample of an ideal gas is tripled, the temperature changes by a factor of

(A) $\frac{1}{3}$ (B) $\frac{1}{9}$ (C) 3 (D) 9

Use the following information for Questions #20 - #22. The most efficient engine ever developed is a supercharged spark-ignited piston-type developed by *Cooper-Bessemer* of Mount Vernon OH, currently owned by GE Corp. *Cooper-Bessemer* should not to be confused with the *Cooper* of Cooper Mini™. These are huge engines used in industry for massive power undertakings; shown below with a human outline for scale. It uses a combination of natural gas and oxygenated air that operates between 1870^oC in the firing chamber and 430^oC at the exhaust into the environment. The net efficiency including frictional losses is such that in one hour an input of $3.0x10^{10}\ J$ of heat produces $1.2x10^{10}\ J$ of useful mechanical energy.

20. What is the Carnot efficiency of this Cooper-Bessemer engine?
(A) 33% (B) 40% (C) 67% (D) 77%

21. What is the *actual* efficiency of this Cooper-Bessemer engine?
(A) 33% (B) 40% (C) 67% (D) 77%

22. What is the power output of this Cooper-Bessemer engine?
(A) $3.33MW$ (B) $5MW$ (C) $6.66MW$ (D) $8.33MW$

Use the following information for Questions #23 - #25. The image below is a PV diagram depiction of a Carnot Cycle.

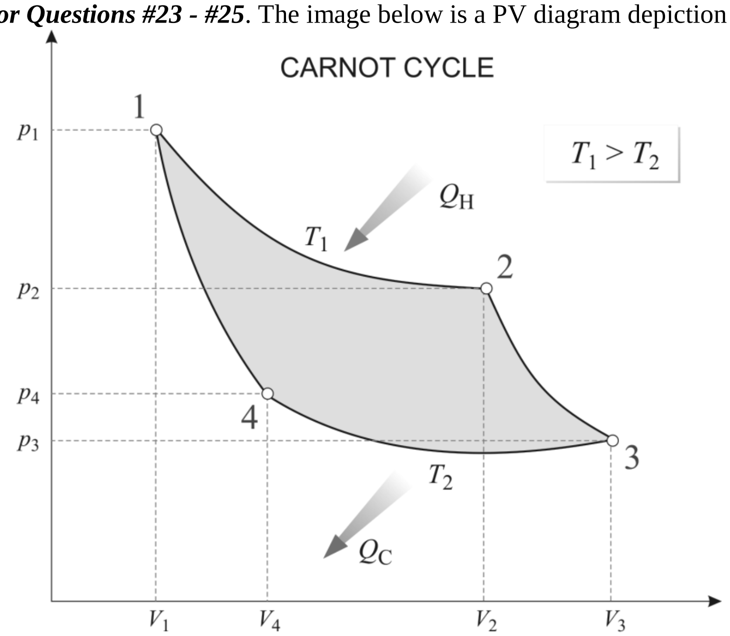


Image Credit: *E. Generalic, https://glossary.periodni.com/glossary.php?en=Carnot+cycle*

23. Which of the following correctly provides the properties of the work done during the process from state ***2*** to state ***3***, ***2→3***?

	Work Done (+ or -)	***Amount of Work Done Depends ONLY on:***
(A)	Negative	T_1 & T_2
(B)	Positive	T_1 & T_2
(C)	Negative	V_2 & V_3
(D)	Positive	V_2 & V_3

24. Which of the following correctly provides the properties of the process from state ***4*** back to state ***1***, ***4→1***?

	Work Done (+ or -)	***Amount of Work Done Depends ONLY on:***
(A)	Negative	T_1 & T_2
(B)	Positive	T_1 & T_2
(C)	Negative	V_4 & V_1
(D)	Positive	V_4 & V_1

25. If this Carnot cycle depicts a coal-fired electric generator running at maximum efficiency, what power would it require to pump heat at a rate of 1600W into the environment from a high-pressure steam supply at 227^oC to exhaust water at 47^oC?
(A) $0.9KW$ (B) $1.6KW$ (C) $2.5KW$ (D) $7.6KW$

PHYSICS II **Golden Rod No Corrections**

JANUARY, 2018

SOLUTIONS

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

Topics AP phy II 2018

January: Fluid Statics and Dynamics; Heat & Thermodynamics: laws of thermodynamics, ideal gases, and kinetic theory, PV diagrams,

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 2018 Season

Thursday January 11, 2018 Thursday February 8, 2018

Thursday March 8, 2018 Thursday April 12, 2018

All areas and schools must complete the April exam and mail in the results by April 27th, 2018

No area may take the April exam during the first week of April or the first week of May

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

What is to be mailed back to our office?

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 2019 Season

Thursday January 10, 2019 Thursday February 14, 2019

Thursday March 14, 2019 Thursday April 11, 2019

AP I and AP 2 PHYSICS FORMULAE Updated 12-22-2017

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		$k = \frac{1}{4\pi\varepsilon_o} = 9.0x10^9 N \cdot m^2/C^2$ $\varepsilon_o = 8.85x10^{-12} C^2/N \cdot m^2$	

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

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

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

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

$\tau = Fr = I\alpha$

$I = \Sigma mr^2$

$L = I\omega$

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

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

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

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

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

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

$P = P_o + \rho gh$

$F_b = \rho Vg$

$A_1 v_1 = A_2 v_2$

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

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

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

FEBRUARY 8, 2018

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.

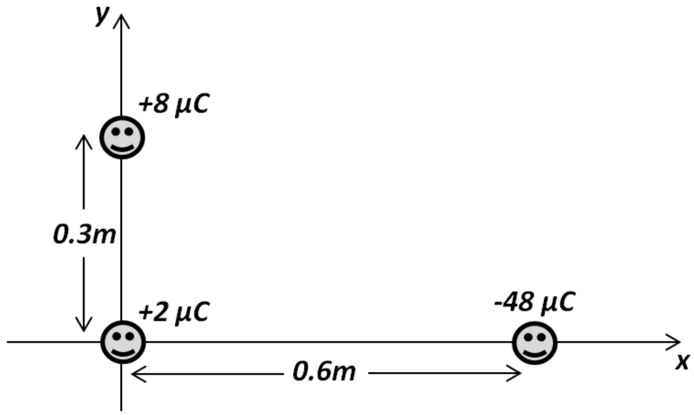
1. In Coulomb's Law, $F_e = k\frac{Q_1Q_2}{r^2}$, the constant of proportionality, k, is defined as $k = \frac{1}{4\pi\varepsilon_o}$. Which of the following represents the unit for ε_o using fundamental SI units?

(A) $\frac{A^2s^4}{kg \cdot m^2}$ (B) $\frac{A^2s^4}{kg \cdot m^3}$ (C) $\frac{A^2s^2}{kg \cdot m^2}$ (D) $\frac{A^2s^2}{kg \cdot m^3}$

2. How many electrons flow through your all-important cell phone charger during the 60 minutes this exam takes, if it is rated at $120V$, $60Hz$, and $50mA$?

(A) $1.1x10^{15}$ (B) $1.1x10^{18}$ (C) $1.1x10^{21}$ (D) $1.1x10^{24}$

Use the following information for Questions #3 - #5: As shown below, three point charges are located on an *xy*-axis.



3. What is the magnitude and direction of the resultant *electrostatic force* acting on the $+2\mu C$ charge at the origin? Consider only the other two charges and no gravitational or Jedi forces.

	Magnitude (N)	***Direction (degrees)***
(A)	1.8	56^o *above x-axis*
(B)	1.8	34^o *above x-axis*
(C)	2.9	56^o *below x-axis*
(D)	2.9	34^o *below x-axis*

4. The $+2\mu C$ charge at the origin is then removed, what is the magnitude and direction of the *electric field* acting at the origin? Consider only the electric charges and no gravitational or Jedi forces.

	Magnitude $\left(N/C\right)$	***Direction (degrees)***
(A)	$1.2x10^6$	56^o *below x-axis*
(B)	$1.44x10^6$	34^o *below x-axis*
(C)	$1.44x10^6$	56^o *below x-axis*
(D)	$1.2x10^6$	34^o *below x-axis*

5. The $+2\mu C$ charge at the origin is still removed, what is the magnitude and direction of the *electric potential* at the origin? Consider only the electric charges and no gravitational or Jedi forces.

	Magnitude (V)	***Direction (degrees)***
(A)	$4.8x10^5$	34^o *below x-axis*
(B)	$9.6x10^5$	34^o *below x-axis*
(C)	$-4.8x10^5$	None
(D)	$-9.6x10^5$	None

6. Two aluminum spheres are suspended from the same point by insulated threads each 100-cm long. Each sphere has a mass of 50-g. An equal electric charge is introduced onto each sphere and they separate and reach equilibrium at a distance pf 80-cm from each other. What is the charge on each sphere?

(A) $4\mu C$ (B) $1.5\mu C$ (C) $4C$ (D) $1.5C$

7. $200J$ of work is required to move a $40C$ point charge from one point to another. What is the potential difference between these two points?

(A) $0.2V$ (B) $5V$ (C) $8{,}000V$ (D) $0V$

8. A $25cm$ conducting thin wire is connected in a straight line between the terminals of a battery with terminal voltage of $10V$. What is the magnitude and direction of the electric field between the terminals?

(A) $2.5 V/m$ toward the positive post (B) $2.5 V/m$ toward the negative post

(C) $40 V/m$ toward the positive post (D) $40 V/m$ toward the negative post

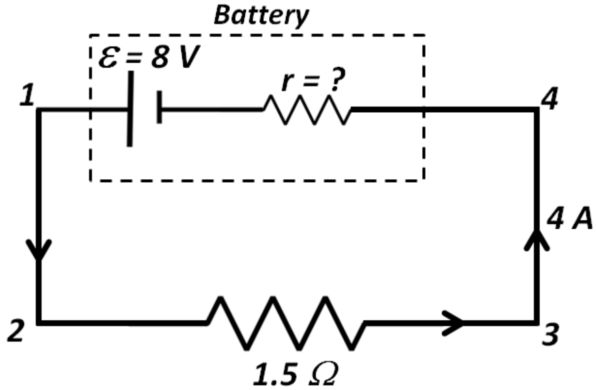
9. During a thunderstorm, a large cloud of area $50km^2$ is $5000m$ above the ground producing an electric field of strength $40{,}000 V/m$. The cloud and ground act like a huge capacitor of capacitance $0.08\mu F$. What is the total charge contained in this cloud?

(A) $16C$ (B) $160C$ (C) $256C$ (D) $2560C$

10. A proton is released from rest inside an electric field of strength $20 KV/m$. What is the displacement of the proton $40\mu s$ after release? Ignore relativistic effects.

(A) $0.15m$ (B) $15.3m$ (C) $1533m$ (D) $1.5x10^6 m$

Use the following information for Questions #11 - #13: The electric schematic below represents a simple circuit where a battery powers a light bulb. The battery is shown within the dashed box and consists of an *emf* of $8V$ and an unknown internal resistance, ***r***. The light bulb is represented by a resistor of value 1.5 C and it is noted that a current of $4\ A$ exists between points ***3*** and ***4***.



11. What is the potential difference measured across the light bulb terminals between points ***2*** to ***3***?

(A) $1.5V$ (B) $2V$ (C) $6V$ (D) $8V$

12. What is the terminal voltage of the battery used?

(A) $1.5V$ (B) $2V$ (C) $6V$ (D) $8V$

13. What is the value of the internal resistance, ***r***, of the battery?

(A) $\frac{1}{2}\,\Omega$ (B) $\frac{4}{3}\,\Omega$ (C) $2\,\Omega$ (D) $\frac{16}{3}\,\Omega$

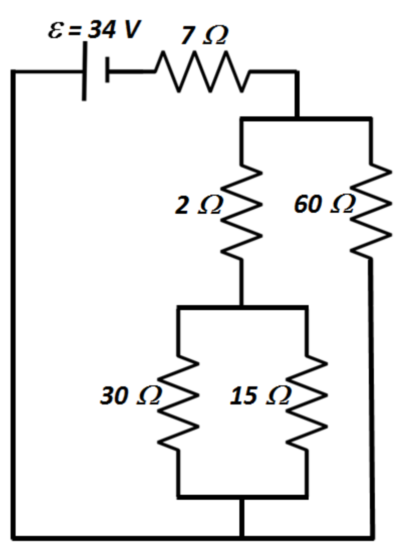
14. What is the current flowing through the $2\,\Omega$ resistor in the circuit shown below

(A) $2\ A$

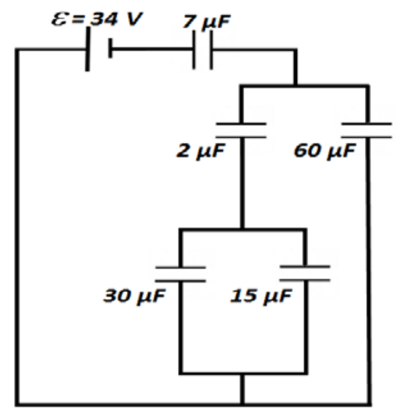
(B) $\frac{5}{3}\ A$

(C) $1\ A$

(D) $\frac{1}{3}\ A$



15. Using the same circuit configuration as used in #14 above, each resistor is replaced by a capacitor, as shown below. What is the total capacitance of the circuit?



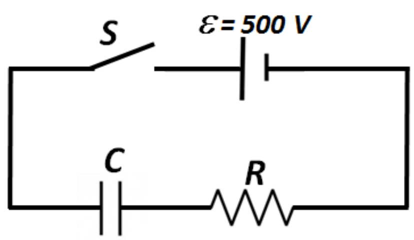
(A) $6.3\ \mu F$
(B) $17\ \mu F$
(C) $61.9\ \mu F$
(D) $114\ \mu F$

16. A flashing Christmas tree light is based on the discharge of a charged capacitor through the bulb. The lamp flashes for a duration of 0.25 seconds during which it produces 0.5 W from the 3 V power supply. What is the capacitance of the capacitor?
(A) $0.004\,F$ (B) $0.014\,F$ (C) $0.04\,F$ (D) $0.125\,F$

17. A $200\ \mu F$ capacitor is slowly charged to $500\,V$ then totally discharged through a $32\ K\Omega$ resistor. Calculate the increase in temperature of the resistor assuming all the thermal energy is retained in the resistor for the short time of the discharge. The mass of the resistor is $2.5\ g$ and is made of a material that has a specific heat of 1670 $J/kg\cdot{}^{o}C$.
(A) $1^{o}C$ (B) $2^{o}C$ (C) $4^{o}C$ (D) $6^{o}C$

18. A $3.0\ \text{n}F$ capacitor is charged with $60\ \text{n}C$ on each plate. The capacitor is then connected to a voltmeter with an internal resistance of $8x10^{5}\ \Omega$. What is the current through the voltmeter immediately after it is connected?
(A) $2.5x10^{-6}\ A$ (B) $2.5x10^{-5}\ A$ (C) $2.5x10^{-4}\ A$ (D) $2.5x10^{-3}\ A$

Use the following information for Questions #19 & #20: As shown below, an uncharged $20\ \mu F$ capacitor, ***C***, is connected in series with a resistor, ***R***, and a battery, ***ℰ***. The battery has $\varepsilon = 500\,V$ with negligible internal resistance. Immediately after the switch, ***S***, is closed, the current through the resistor is $2x10^{-4}\ A$.



19. What is the resistance of the resistor?
(A) $2.5\ \text{K}\Omega$ (B) $10\ \text{K}\Omega$ (C) $2.5\ \text{M}\Omega$ (D) $10\ \text{M}\Omega$

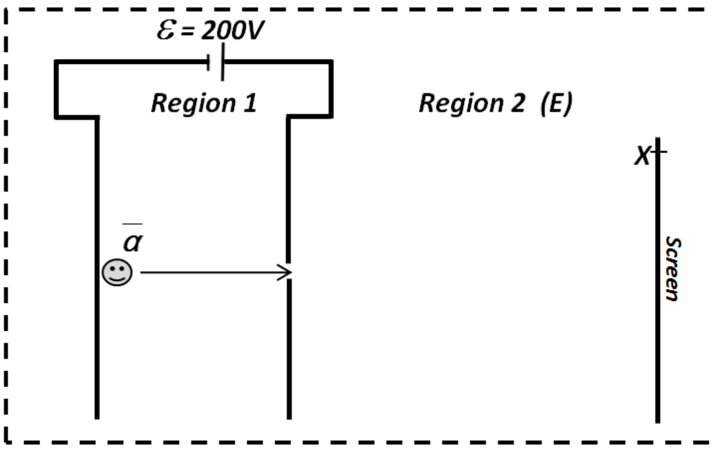
20. After a long time, the current drops to zero. What is the charge stored on the capacitor?
(A) $1\ \mu C$ (B) $100\ \mu C$ (C) $0.01\,C$ (D) $0.1\,C$

Use the following information for Questions #21 & #22: *Anti*-matter, unlike that which is depicted in Hollywood movies like *Angels & Demons,* is a very common creation in linear accelerators and nuclear reactions. Anti-matter is simply regular matter with the same properties of size and mass, but with the opposite electrical charge; protons have positive charge whereas anti-protons are negative, electrons have a negative charge whereas anti-electrons (called *positrons*) have a positive charge. With this in mind, an anti-alpha particle, $\overline{\alpha}$, essentially the nucleus of an anti-helium atom, consisting of two anti-protons (each with electric charge of *-1*) and two anti-neutrons each with no net charge, starts at rest as shown below. Such anti-alpha particles were observed for the first time in 2011 at the National Brookhaven Laboratory. This anti-alpha is then accelerated through a potential difference of 200*V* within ***Region 1*** where it is aimed through a tiny opening into ***Region 2***. ***Region 2*** also has an electric field ***E***, but is independent of and isolated from ***Region 1***. After traversing through ***Region 2***, the anti-alpha particle strikes the screen at point ***X***. Use the following information, *if needed*.

Mass of a proton = Mass of an anti-proton = $1.67x10^{-27}\,kg$

Mass of an electron = Mass of an anti-electron (positron) = $9.11x10^{-31}\,kg$

Mass of a neutron (AND anti-neutron) = $1.67x10^{-27}\,kg$



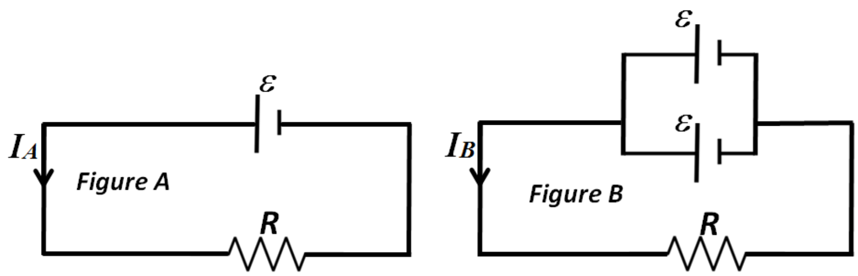
21. With what speed does the anti-alpha particle enter the opening between ***Region 1*** and ***Region 2***?

(A) $9.79x10^4\ m/s$ (B) $1.38x10^5\ m/s$ (C) $1.96x10^5\ m/s$ (D) $3.36x10^5\ m/s$

22. In what direction is the electric field ***E*** within ***Region 2***?

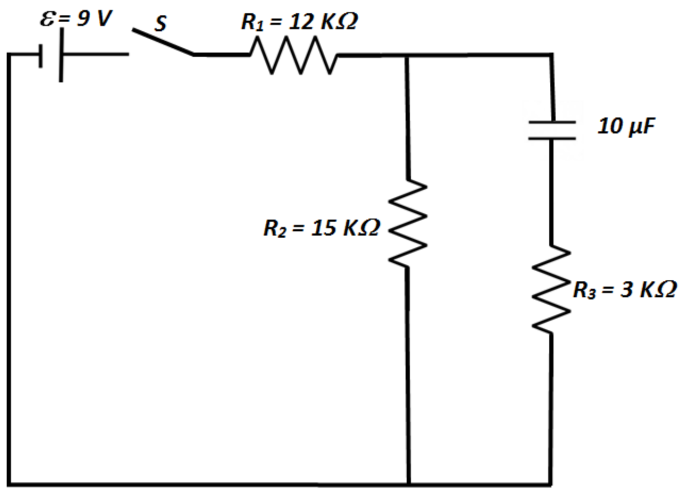
(A) Upward toward the top of the page
(B) Downward toward the bottom of the page
(C) Toward the left of the page
(D) Toward the right of the page

23. As shown below in ***Figure A***, a battery with *emf* of $\mathcal{E}$ is connected to a resistor $\boldsymbol{R}$ in series providing a current I_A. If you then add an identical battery in parallel to the original battery then in series with the same resistor $\boldsymbol{R}$, ***Figure B***, what is the relationship between the original *emf* of $\mathcal{E}$ and original current I_A? Assume the batteries have negligible internal resistance.



(A) ***Figure B*** supplies twice the *emf* and twice the current as ***Figure A***.
(B) ***Figure B*** supplies half the *emf* and twice the current as ***Figure A***.
(C) ***Figure B*** supplies the same *emf* and the same current as ***Figure A***.
(D) ***Figure B*** supplies the same *emf* and twice the current as ***Figure A***.

Use the following information for Questions #24 & #25: The circuit pictured below contains one battery, three resistors, one switch ***S***, and one capacitor. The switch is closed and the circuit is allowed to reach steady state with the capacitor fully charged.



24. What is the current in all three resistors?

	R_1	R_2	R_3
(A)	333 μA	333 μA	Zero
(B)	185 μA	148 μA	Zero
(C)	333 μA	55.5 μA	277.5 μA
(D)	333 μA	277.5 μA	55.5 μA

25. What is the charge on the capacitor?
(A) 30 μC (B) 40 μC (C) 50 μC (D) 90 μC

AP I and AP 2 PHYSICS FORMULAE Updated 12-22-2017

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		$k = \frac{1}{4\pi\varepsilon_o} = 9.0x10^9 N \cdot m^2/C^2$ $\varepsilon_o = 8.85x10^{-12} C^2/N \cdot m^2$	

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

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

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

$1rev = 2\pi rad = 360°$

$\tau = Fr = I\alpha$

$I = \Sigma mr^2$

$L = I\omega$

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

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

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

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

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

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

$P = P_o + \rho gh$

$F_b = \rho Vg$

$A_1 v_1 = A_2 v_2$

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

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

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

p = momentum

λ = wavelength

ϕ = work function

PHYSICS II **Golden Rod** **No Corrections**

FEBRUARY 8, 2018

SOLUTIONS

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

Topics AP phy II 2018

January: Fluid Statics and Dynamics; Heat & Thermodynamics: laws of thermodynamics, ideal gases, and kinetic theory, PV diagrams,

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 2018 Season

Thursday February 8, 2018

Thursday March 8, 2018 Thursday April 12, 2018

All areas and schools must complete the April exam and mail in the results by April 27th, 2018

No area may take the April exam during the first week of April or the first week of May

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

What is to be mailed back to our office?

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 2019 Season

Thursday January 10, 2019 Thursday February 14, 2019

Thursday March 14, 2019 Thursday April 11, 2019

PHYSICS II **Golden Rod No Corrections**

MARCH 8, 2018

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. Use** ***conventional current*** **unless specifically told otherwise.**

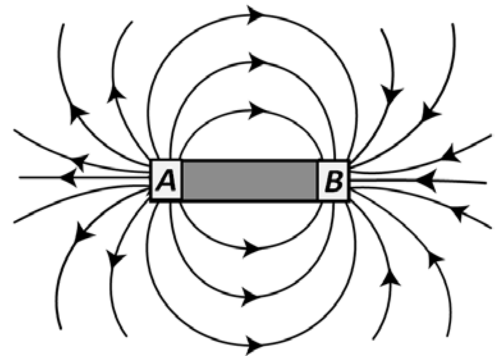
1. Below is a sketch of the interaction of the two ends of a typical bar magnet with the two ends labeled ***A*** and ***B***. Using the conventional definition for field lines, which pole is which?

(A) ***A*** is south, ***B*** is north

(B) ***A*** is north, ***B*** is south

(C) This is a trick. The image is of a magnetic monopole where both ***A*** and ***B*** are the same pole; either north OR south.

(D) You cannot make this determination without the interaction of a known magnetic source to test the poles individually.



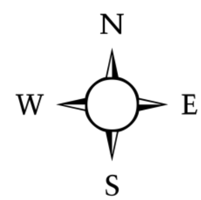
2. Using the magnetic compass convention of N-S-E-W with reference to this test paper with North being toward the top of this paper, which of the following will result in no net magnetic force acting on a single proton when interacting with a magnetic field oriented toward North?

(A) The proton is moving at a constant speed toward the South.

(B) The proton is moving at a constant speed toward the West.

(C) The proton is moving at a constant speed toward the upper right side of the page; toward the North-East, at a 45^o angle between North and East.

(D) The proton is moving at a constant speed into the plane of the page.



3. In a particle accelerator, a proton is moving in a straight line at $0.1c$ $\left(\frac{1}{10} \text{ the speed of light} = 3x10^7\ \frac{m}{s} \right)$ directly south on the surface of the Earth. It enters a region where a magnetic field of strength $10T$ directed vertically upward. What is the magnitude and direction of the force on the proton while in the magnetic field? Ignore relativistic effects.

(A) $4.8x10^{-11}N$ horizontally to the west

(B) $4.8x10^{-11}N$ horizontally to the east

(C) $4.8x10^{-19}N$ vertically upward

(D) $4.8x10^{-19}N$ vertically downward

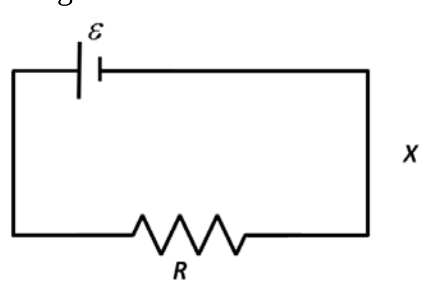
4. In the simple electrical circuit shown below, in what direction is the magnetic field due to the current in the wire at point ***X***?

(A) Toward the top of the page.

(B) Toward the bottom of the page.

(C) Out from the plane of the page toward you.

(D) Into the plane of the page away from you.



5. A square loop of wire 4-cm on each side is lying on a horizontal physics lab bench. An electromagnet directly above the loop is turned on causing a uniform magnetic field that increases in strength oriented vertically downward through the loop. The magnetic field increases from zero to $0.5T$ in $200ms$. Calculate the average *emf* induced in the loop.

(A) $0.004V$ (B) $0.04V$ (C) $0.4V$ (D) $4V$

6. A horizontal conducting metal meter stick is released from rest and falls near the surface of the Earth. It falls through a region where a magnetic field of strength $0.2T$ exists perpendicular to the length of the stick. How far has the stick fallen when it experiences an induced *emf* of $1.2V$?

(A) $0.4m$ (B) $0.8m$ (C) $1.2m$ (D) $1.8m$

Use the following information for Questions #7 & #8: *Anti*-matter, as mentioned in the February 2018 NJ Science League Exam, is a very common creation in linear accelerators and nuclear reactions. Anti-matter is simply regular matter with the same properties of size and mass, *but with the opposite electrical charge*; protons have positive charge whereas anti-protons are negative, electrons have a negative charge whereas anti-electrons (called *positrons*) have a positive charge. Such anti-alpha particles were first observed in 2011 at the National Brookhaven Laboratory.

With this in mind, an anti-alpha particle, $\overline{\alpha}$, essentially the nucleus of an anti-helium atom, consisting of two anti-protons (each with electric charge of *-1*) and two anti-neutrons each with no net charge, starts at rest as shown below. It is accelerated through a potential difference of $900V$ within ***Region 1*** where it is aimed through a tiny opening into ***Region 2***. ***Region 2*** has a magnetic field ***B*** of strength $0.6T$, oriented perpendicularly into the page. This magnetic field causes the anti-alpha particle to follow a circular path. Use the following information, *if needed*.

Mass of a *proton* = Mass of an *anti-proton* = Mass of a *neutron* = Mass of an *anti-neutron* = $1.67x10^{-27}kg$

Mass of an electron = Mass of an anti-electron (positron) = $9.11x10^{-31}kg$

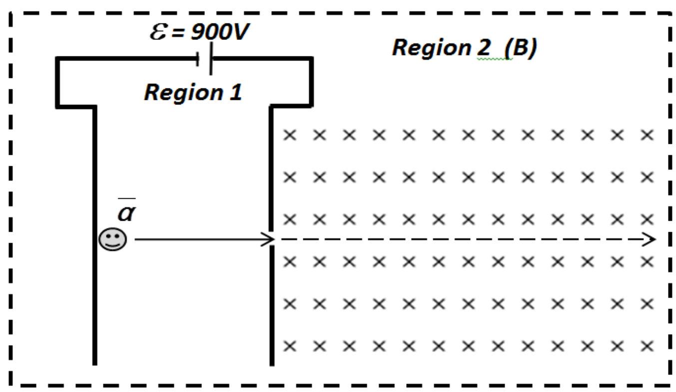
7. What is the radius of the circle the $\overline{\alpha}$ follows inside ***Region 2***? The dotted line in ***Region 2*** represents a continuation of the original path of the anti-alpha.

(A) $7x10^{-3}m$

(B) $1.4x10^{-3}m$

(C) $1.0x10^{-2}m$

(D) $1.4x10^{-2}m$



8. What is the orientation of the circular path the $\overline{\alpha}$ follows in ***Region 2*** with respect to the dotted line and the plane of the page?

(A) In the plane of the page *above* the dotted line.

(B) In the plane of the page *below* the dotted line.

(C) Perpendicular to the plane of the page going away from you (*into* the page)

(D) Perpendicular to the plane of the page going toward you (*out of* the page)

9. A screen is set up two meters from a diffraction grating. The spacing between the slits of the grating is $0.03mm$ and monochromatic light of wavelength $560nm$ is incident upon it. What is the distance between adjacent bright spots on the screen?

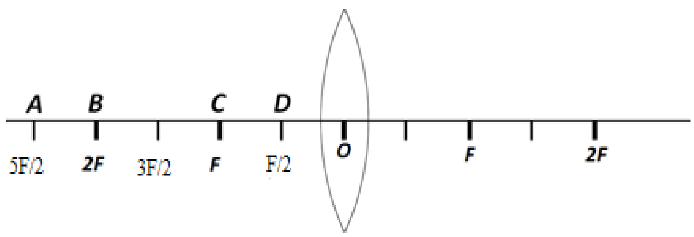
(A) $1.2cm$ (B) $2.5cm$ (C) $3.7cm$ (D) $5.0cm$

10. Which of the following images cannot be formed by a single converging lens? The descriptors *inverted*, *upright*, *same size*, *larger* and *smaller* are all in reference to the object.

(A) Real, inverted, larger (B) Real, inverted, same size
(C) Virtual, upright, larger (D) Virtual, upright, same size

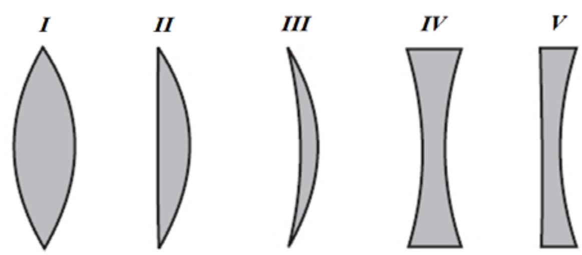
11. The below diagram represents a labeled principle axis and a double convex converging lens with geometric center at labeled point ***O***. Which of the labeled positions (***A***, ***B***, ***C***, or ***D***) will produce the largest image for an object of height ***H***? (Do not consider any other points other than the four labeled.)

(A) ***A***
(B) ***B***
(C) ***C***
(D) ***D***



12. Which of the following thin glass lenses can form a real image?

(A) ***I*** only
(B) ***I*** & ***IV*** only
(C) ***I***, ***II***, & ***III*** only
(D) ***IV*** & ***V*** only



13. Dentists utilize a small concave mirror at the end of a thin metal rod to "see" the back of each tooth more easily. If your dentist uses a concave spherical mirror with a radius of curvature of $40mm$ to investigate a cavity on the back of one of your front teeth, what are the properties of the image he sees if the mirror is placed $10mm$ from the cavity?

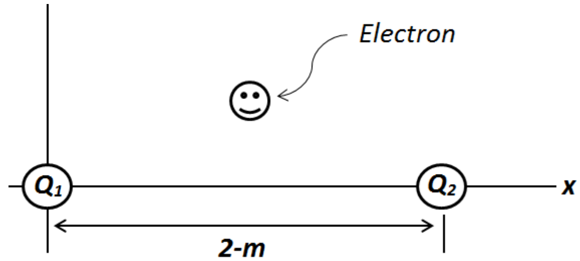
	Type of Image	*Size of Image*	*Location of Image*	*Orientation*
(A)	Virtual	Larger than Cavity	20mm behind mirror	Upright
(B)	Virtual	Larger than Cavity	20mm in front of mirror	Inverted
(C)	Real	Smaller than Cavity	10mm behind mirror	Inverted
(D)	Real	Larger than Cavity	10mm in front of mirror	Upright

14. As the distance between the openings in a diffraction grating increases, what happens to the spacing between the bright spots on a screen at some large distance away? Assume the width of the slits and the wavelength of the incident light remain constant.

(A) Spacing between bright areas also increases.
(B) Spacing between bright areas decreases.
(C) Spacing between bright areas remains constant, but the bright areas get dimmer.
(D) Spacing between bright areas remains constant, but the bright areas get brighter.

15. Two positive point charges, Q_1 & Q_2, lie on the x-axis as shown below. $Q_1 = +15\mu C$ and is located at the origin whereas $Q_2 = +9\mu C$ and is located at a position of $+2m$. At what position *on the x-axis* can a single electron be placed so that the electron experiences a zero net electric force caused by the two positive charges?

(A) $0.87m$
(B) $1m$
(C) $1.13m$
(D) $8.87m$

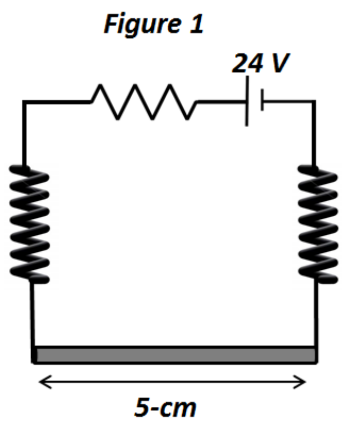


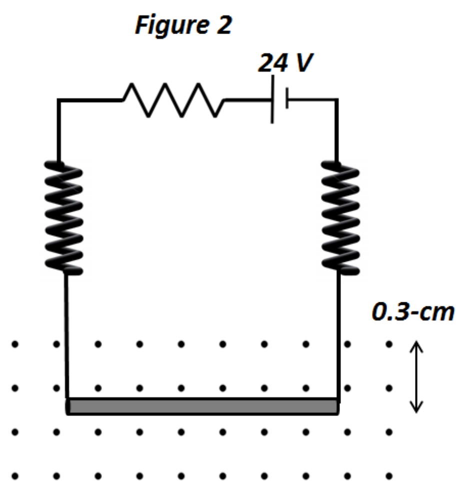
16. A common magnetic field unit is the *Gauss* **G**. It is related to the SI magnetic unit, the *Tesla* ***T***, through the conversion $1T = 1x10^4 G$. What is the *Gauss* as expressed in *fundamental* SI units?
NOTE: SI fundamental units are ***A*** (Ampere), ***cd*** (candela), ***K*** (Kelvin), ***kg*** (kilogram), ***m*** (meter), ***mol*** (mole), and ***s*** (second).

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

17. The circuit shown below consists of a $24V$ battery in series with a resistor, a solid metal conducting rod (shown as the bottom grey rod), and two identical ideal springs. The total resistance of the circuit is 12Ω. The solid metal conducting rod has a mass of 10-grams and a length of 5-cm. The springs stretch from a relaxed initial length by a distance of $0.5cm$ under the weight of the metal bar (*Figure 1*). When a magnetic field (perpendicular to and pointing out of the plane of the page) is introduced (*Figure 2*), the springs stretch an additional $0.3cm$. What is the magnitude of the magnetic field?

(A) $0.006T$
(B) $0.06T$
(C) $0.6T$
(D) $6T$

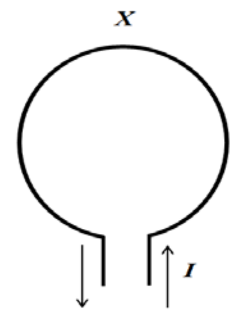




18. A coil of wire consists of 200 turns and has a total resistance of 2Ω. Each turn is in the shape of a circle of diameter 8-cm. A uniform magnetic field directed perpendicularly to the plane of the coil is then turned on. The field changes consistently from $0T$ to $5T$ in $1.8\sec$. What is the magnitude of the induced *emf* in the coil during these $1.8\sec$?

(A) $2.8V$ (B) $5.6V$ (C) $8.4V$ (D) $11.2V$

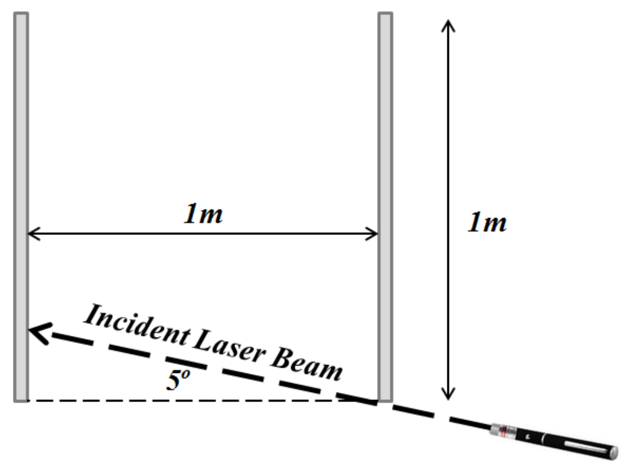
19. A loop of wire has an electric current ***I*** that runs counterclockwise through the loop, as shown below. At point ***X***, directly above the loop, in what direction is the induced magnetic field?



(A) Perpendicularly out of the page.
(B) Perpendicularly into the page.
(C) To the left of the page.
(D) To the right of the page.

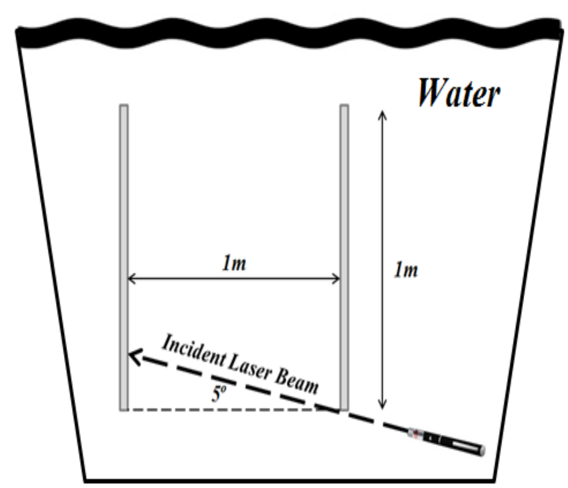
20. As shown, two vertically oriented mirrors are 1-m apart. Each mirror is 1-m tall. A green laser beam, indicated by the bold dashed line and arrow, is aimed to just clear the bottom of the right mirror and strike the left mirror. The laser beam makes a 5^o angle above the horizontal. How many times will this laser beam reflect from the left and right mirrors before exiting at the top of the mirrors?

	Number of LEFT Mirror Reflections	***Number of RIGHT Mirror Reflections***
(A)	5	5
(B)	6	6
(C)	5	6
(D)	6	5



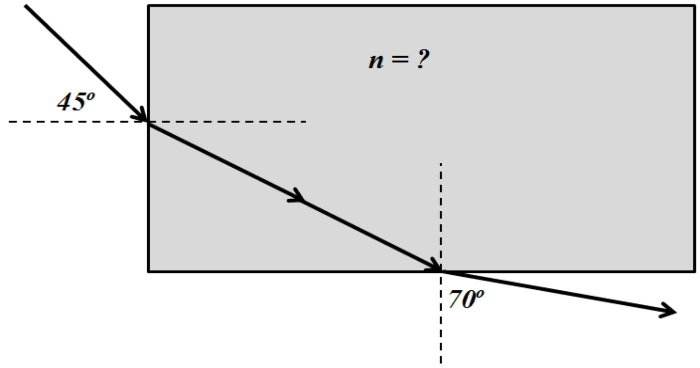
21. If the entire mirror / laser apparatus used in #20 above is now submerged into a large container full of clean water, what happens to the numbers of reflections on each mirror? Index of refraction of clean water is 1.33.

(A) The number of reflections *increases* on both mirrors.
(B) The number of reflections *decreases* on both mirrors.
(C) The number of reflections increases on the right mirror, but remains the same on the left mirror.
(D) The number of reflections remains the same on both mirrors.



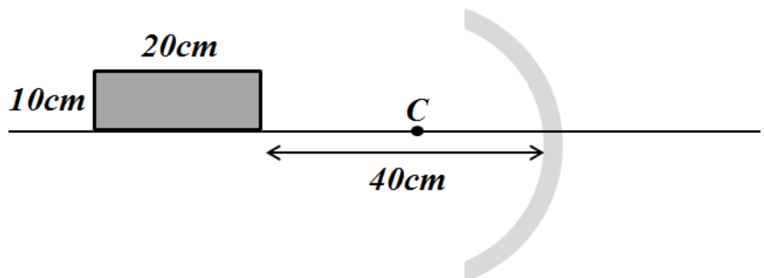
22. A laser beam travelling through air is aimed at a block of transparent material at $\mathbf{45^o}$ as shown below. The beam passes through the material and exits back into air at an angle of $\mathbf{70^o}$. What is the index of refraction of this material?

(A) 0.75
(B) 1.18
(C) 1.32
(D) 1.50



Use the following information for Questions #23 & #24: A box measuring $20cm$ in length and $10cm$ in height is placed so its closest edge is $40cm$ from a spherical concave mirror with radius of curvature $C = 20cm$.

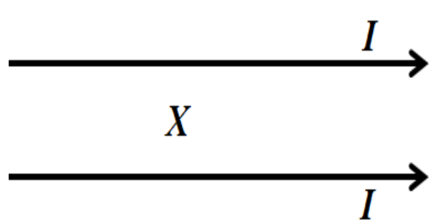
23. Which set of descriptors is correct for the image formed?
(A) Real, upright, smaller.
(B) Real, inverted, smaller
(C) Virtual, upright, larger
(D) Real, inverted, larger



24. What is the length of the image produced?
(A) $1.33cm$ (B) $2.67cm$ (C) $10cm$ (D) $20cm$

25. Two very long parallel conducting wires each have an equal electric current in the same direction, as shown. Directly at midpoint between the wires and equidistance to each wire, designated by point ***X***, the induced magnetic field can be described by which of the following?

(A) The magnitude is non-zero and directed perpendicularly out of the page.
(B) The magnitude is non-zero and directed perpendicularly into the page.
(C) The magnitude is non-zero and directed parallel to the wires.
(D) The magnitude is zero and therefore has no direction.



AP I and AP 2 PHYSICS FORMULAE Updated 12-22-2017

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		$k = \frac{1}{4\pi\varepsilon_o} = 9.0x10^9\,N \cdot m^2/C^2$ $\varepsilon_o = 8.85x10^{-12}\,C^2/N \cdot m^2$	

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

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

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

$\Delta U_E = q\Delta V$

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

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

$V = IR$

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

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

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

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

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

$\tau = Fr = I\alpha$

$I = \Sigma mr^2$

$L = I\omega$

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

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

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

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
$c_{water} = 4186 \frac{J}{kg^\circ K}$
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

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

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

$P = P_o + \rho gh$

$F_b = \rho Vg$

$A_1 v_1 = A_2 v_2$

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

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

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
p = momentum
λ = wavelength
ϕ = work function

PHYSICS 2 **Golden Rod No Corrections**

MARCH, 2018

SOLUTIONS Deadline: All March exam results must be post marked by March 16th or scan the record sheet and email to newjsl@ptd.net or the scores will not count.

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

Topics AP phy II 2018

January: Fluid Statics and Dynamics; Heat & Thermodynamics: laws of thermodynamics, ideal gases, and kinetic theory, PV diagrams,

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 2018 Season

Thursday March 8, 2018 Thursday April 12, 2018

All areas and schools must complete the April exam and mail in the results by April 27th, 2018

No area may take the April exam during the first week of April or the first week of May

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

What is to be mailed back to our office?

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 2019 Season

Thursday January 10, 2019 Thursday February 14, 2019

Thursday March 14, 2019 Thursday April 11, 2019

PHYSICS II Golden Rod NO Corrections:
APRIL 12, 2018

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. The fictional metal *vibranium* Vi, is all the rage lately. It is the metal that makes Disney®'s (Marvel Comic®'s) Black Panther's suit and is mined in his fictional country of Wakanda. Vibranium first appeared in Daredevil #13 back in 1966, a creation of Stan Lee at Marvel Comics®. It has the unique properties of cutting through any other metal (except Wolverine's *adamantium*, of course) and absorbing all forms of energy. It is the basis of Captain America's shield. It is claimed to be element number 121, right between *unobtainium* from "Pandora" and *gravitonium* from "Agents of SHIELD".
What is the largest wavelength of electromagnetic radiation that can eject an electron from the surface of *vibranium* given that it has an astonishing work function of $235eV$?

(A) $0.053nm$ (B) $5.3nm$ (C) $530nm$ (D) $5300nm$

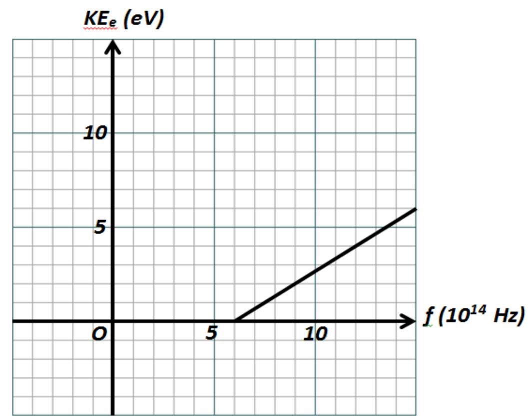
2. The graph below represents the maximum kinetic energy KE_{Max} of photoelectrons ejected from some unknown metal surface versus the incident electromagnetic frequency f. Approximately, what is the value (*with no unit attached*) of the work function ϕ of the metal surface?

(A) 4

(B) 6

(C) $4x10^{14}$

(D) $6x10^{14}$



3. What is the maximum kinetic energy of electrons ejected from a calcium surface by $420nm$ incident light if calcium has a work function of $2.71eV$?

(A) $0.246eV$ (B) $0.271eV$ (C) $2.46eV$ (D) $2.71eV$

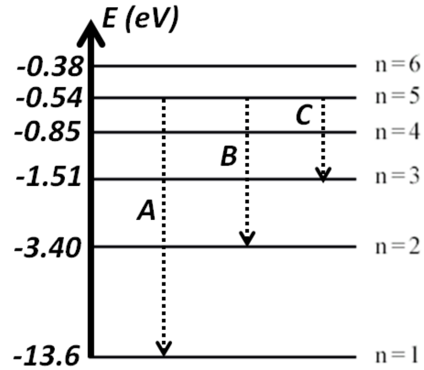
4. A single photon collides with a single free electron that was initially at rest. The free electron then recoils with a small velocity and the photon is deflected and moves off in some other direction. Compared to the original photon, which statement below is true about the "new" scattered photon?

(A) Its speed is reduced
(B) Its frequency is increased
(C) Its energy is increased
(D) Its wavelength is increased

5. An isolated Uranium nucleus $^{238}_{92}U$ follows the following decay sequence: $\alpha,\ \beta^-,\ \beta^+,\ \alpha,\ and\ \alpha$. Which of the following represents the correct nomenclature for the resulting nucleus where '***X***' represents the element symbol.

(A) $^{226}_{84}X$ (B) $^{228}_{84}X$ (C) $^{226}_{86}X$ (D) $^{226}_{88}X$

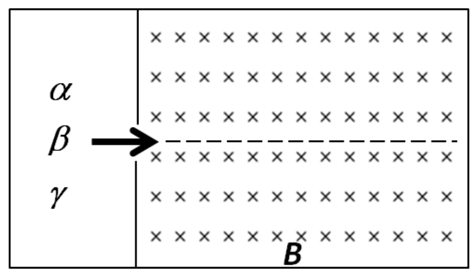
Use the following information for Questions #6 & #7: The diagram below represents some of the many electron energy levels of a typical hydrogen atom. The numbers on the left represent the energy of the labeled level in *eV* relative to the atom ionization energy and the numbers on the right are simply the number of the level (quantum number) with $n = 1$ being ground state. There are three energy level transitions labeled as ***A***, ***B***, & ***C*** with dashed arrows.



6. Visible light for humans is considered anything from $400nm - 700nm$ in wavelength. Which labeled transition would represent the release of a visible photon?
(A) ***A***
(B) ***B***
(C) ***C***
(D) None of them

7. If an electron begins at $n = 6$, how many *possible* transition steps does it have if it ends up at ground state $n = 1$?
(A) 1 (B) 5 (C) 10 (D) 15

8. You have an apparatus that can "shoot" the three types of nuclear radiations, alpha (α), beta (β), and gamma (γ), into a magnetic field ***B***, as shown. The magnetic field is perpendicular to the plane of the page. Which entry in the table correctly describes the path of the α, β, & γ once they enter the magnetic field?



	Alpha	***Beta***	***Gamma***
(A)	Follows a circular path *upward* above the dotted path	Follows a circular path *downward* below the dotted path	Follows a circular path *upward* above the dotted path
(B)	Follows a circular path *downward* below the dotted path.	Follows a circular path *upward* above the dotted path	Continue in a straight line path
(C)	Follows a circular path *upward* above the dotted path	Follows a circular path *downward* below the dotted path	Follows a circular path *downward* below the dotted path
(D)	Follows a circular path *upward* above the dotted path	Follows a circular path *downward* below the dotted path	Continue in a straight line path

9. What is the energy in MeV emitted in one alpha $(m_\alpha = 4.002602u)$ decay of $^{239}_{94}Pu$ $(m_{Pu239} = 239.052157u)$ into $^{235}_{92}U$ $(m_{U235} = 235.043924u)$?
(A) $5.25MeV$ (B) $5.63MeV$ (C) $5.6x10^{-3}MeV$ (D) $5.6x10^{-4}MeV$

10. Which of the following represents the correct equation for a single alpha decay of $^{249}_{98}Cf$ where "*X*" indicates the element symbol for the resulting nucleus?

(A) $^{249}_{98}Cf \rightarrow {}^{4}_{2}He + {}^{247}_{96}X$ (B) $^{249}_{98}Cf \rightarrow {}^{2}_{2}He + {}^{247}_{96}X$
(C) $^{249}_{98}Cf \rightarrow {}^{4}_{2}He + {}^{245}_{96}X$ (D) $^{249}_{98}Cf \rightarrow {}^{4}_{4}He + {}^{247}_{94}X$

11. ${}_{0}^{1}n+{}_{92}^{235}U\rightarrow{}_{36}^{89}Kr+{}_{56}^{144}Ba+3{}_{0}^{1}n+\gamma$ represents a possible fission reaction in a modern nuclear fission power plant. One Uranium nucleus ${}_{92}^{235}U$ is induced by an incident neutron ${}_{0}^{1}n$ to split into one Krypton nucleus ${}_{36}^{89}Kr$, one Barium nucleus ${}_{56}^{144}Ba$, three free neutrons $3{}_{0}^{1}n$, and gamma radiation γ. Which of the following mathematical statements about the masses involved is correct?

(A) $m_n+m_U=m_{Kr}+m_{Ba}+m_{3n}$ (B) $m_n+m_U>m_{Kr}+m_{Ba}+m_{3n}$ (C) $m_n+m_U<m_{Kr}+m_{Ba}+m_{3n}$
(D) Impossible to tell without knowing how many gamma photons are produced.

12. A fusion bomb uses neutrons from a fission reaction to create tritium ${}_{1}^{3}H$ fuel following the reaction ${}_{0}^{1}n+{}_{3}^{6}Li\rightarrow{}_{1}^{3}H+{}_{2}^{4}He$. What is the energy released by this reaction?

Use: $m_{{}_{2}^{4}He}=4.002602u$, $m_n=1.008665u$, $m_{{}_{3}^{6}Li}=6.015121u$, & $m_{{}_{1}^{3}H}=3.016050u$

(A) $4.78\ eV$ (B) $4.78\ keV$ (C) $4.78\ MeV$ (D) $4.78\ GeV$

13. A high-power laser fusion system is being developed at the University of New South Wales, Australia. It uses lasers to fuse together small nuclei similar to how the immense gravity of a star does it. The laser system produces $100MJ$ pulse of laser light for $1ns$ (nano-second). How many photons are in this short duration pulse if the wavelength is $106nm$?

(A) $5.6x10^{12}$ (B) $5.63x10^{17}$ (C) $5.6x10^{21}$ (D) $5.33x10^{25}$

14. You are performing a photoelectric effect lab in physics class. You are illuminating a metal surface with a light source of wavelength λ and intensity ***I***. You measure the ejected photoelectrons from the surface with maximum speed $v_{\max}$. Which statement below would produce photoelectrons being ejected from the same surface with a maximum speed of twice the original noted, $2v_{\max}$?

(A) Double the wavelength of the incident light (B) Double the intensity of the incident light
(C) Cut the wavelength of the incident light in half to $\lambda/2$
(D) Cut the wavelength of the incident light to 25% of the original to $\lambda/4$

15. According to the Standard Model of Fundamental Particles, the neutron consists of
(A) one proton plus one electron (B) one electron plus one anti-electron (positron)
(C) two neutrinos plus one quark (D) three quarks

16. An isolated nucleus of Cobalt ${}_{27}^{59}Co$ spontaneously decays via an alpha particle. If the alpha particle is ejected with a speed of $3x10^{7}\ m/s$ (one-tenth the speed of light), what is the speed of the resulting nucleus? Ignore relativistic effects and use the whole-number masses for the particles involved.

(A) $2.03x10^{6}\ m/s$ (B) $2.18x10^{6}\ m/s$ (C) $3x10^{6}\ m/s$ (D) $3x10^{7}\ m/s$

17. The magnitude of momentum of a single isolated proton in a linear accelerator is the same as the magnitude of momentum of a photon that has energy of $3x10^{-14}\ J$. What is the speed of the proton? Ignore any relativistic effects on the moving proton.

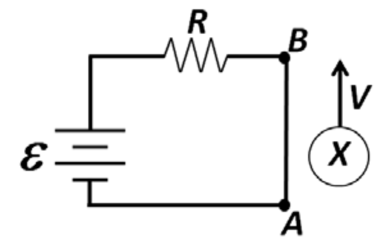
(A) $3x10^{4}\ m/s$ (B) $6x10^{4}\ m/s$ (C) $9x10^{4}\ m/s$ (D) $1.2x10^{5}\ m/s$

18. A Thorium nucleus spontaneously decays into an Actinium nucleus. The decay equation is written as ${}_{90}^{232}Th\rightarrow{}_{89}^{232}Ac+X$. What is the '$X$?'

(A) Positron (B) Electron (C) Proton (D) Anti-Proton

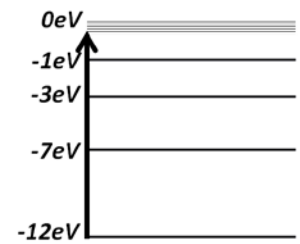
19. According to the UN's *International Atomic Energy Agency* (IAEA), the current total worldwide explosive yield of nuclear weapons is $7.5GT$ ($7.5\ Gigaton$). This is, surprisingly, only 15% of the yield that existed during the 1970's, according to what "they" tell us. $1GT = 1,000MT$ and the *T* is a metric tonne, $1T = 1,000kg$, *not* the American $2000\,pound$ thing. Convert this current level of potential amount of energy to kilowatt-hours, $kW \cdot hr$. One Megaton has the energy equivalent of $4.2x10^{15}J$.
(A) $8.75x10^{12}$ (B) $3.15x10^{13}$ (C) $8.75x10^{18}$ (D) $3.15x10^{19}$

20. In the diagram shown below, a simple circuit consists of a battery, one resistor, and wires. There is one isolated electron *outside the circuit* at point ***X*** moving with speed ***V*** toward the top of the page, parallel to the wire labeled from points ***A*** to ***B***. The magnetic force acting on the electron caused by the circuit at the instant it is at point ***X*** is



(A) directed into the page away from you.
(B) directed out of the page toward you.
(C) directed toward the left of the page.
(D) directed toward the right of the page.

21. The diagram below represents the energy transitions of a hypothetical atom. An electron in ground state is excited up to the $1eV$ state and then transitions back to ground state by emitting exactly two photons. Which of the following cannot be the frequency of one of the two emitted photons?



(A) $4.83x10^{14}Hz$
(B) $9.66x10^{14}Hz$
(C) $1.21x10^{15}Hz$
(D) $1.45x10^{15}Hz$

22. The mass of an Argon atom ${}^{40}_{18}Ar$ is 10 times that of a Helium atom ${}^{4}_{2}He$. A sample of gas that contains equal amount of both Argon and Helium gases is at temperature ***T*** under pressure ***P***. The average speed of an Argon atom in this sample is ***v***. Relative to ***v***, what is the average speed of a Helium atom in this sample?
(A) $v/\sqrt{10}$ (B) v (C) $\sqrt{10}\ v$ (D) $10v$

23. Which process provided in the choices below requires the largest energy?

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

$L_{f\,(ice)} = 334kJ$ & $L_{V\,(steam)} = 2,230kJ$

(A) Melt one kilogram of ice at 0^oC. (B) Raise the temperature of one kilogram of ice from -50^oC to -10^oC
(C) Raise the temperature of one kilogram of water from 10^oC to 50^oC
(D) Vaporize one kilogram of water at 100^oC into steam at 100^oC

24. In June 2017, a team of researchers announced that fossils found in a cave in Morocco are from an early modern human and is now considered the oldest Homo Sapien bones ever found. Carbon-14 $\left({}^{14}_{6}C\right)$ is accurate only to 60,000 years ago, so another radioactive method was employed. Using a complex system involving three different radioactive potassium isotopes with an average half-life of 50,000 years, it was noted the bones contained about $1/64$ the amount of these isotopes as in living tissue. Approximately how old are these bones? (NOTE: These are close approximations of the true values.)
(A) 50,000 years (B) 100,000 years (C) 300,000 years (D) 3,200,000 years

25. A $100kg$ cube of uniform density floats with 25% of the object above water in a large tank holding $2500m^3$ of fresh water. What is the buoyant force acting on the cube?
(A) $2500\ N$ (B) $1000\ N$ (C) $750\ N$ (D) $250\ N$

AP I and AP 2 PHYSICS FORMULAE Updated 12-22-2017

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		$k = \frac{1}{4\pi\varepsilon_o} = 9.0x10^9\ N \cdot m^2/C^2$ $\varepsilon_o = 8.85x10^{-12}\ C^2/N \cdot m^2$	

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

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

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

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

$\tau = Fr = I\alpha$

$I = \Sigma mr^2$

$L = I\omega$

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

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

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

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

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

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

$P = P_o + \rho gh$

$F_b = \rho Vg$

$A_1 v_1 = A_2 v_2$

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

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

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

PHYSICS 2 **Golden Rod** **NO Corrections**

APRIL 12, 2018

SOLUTIONS

All schools and areas must finish the April exam and post mark or scan all results by April 30th.

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

Topics AP phy II 2018

January: Fluid Statics and Dynamics; Heat & Thermodynamics: laws of thermodynamics, ideal gases, and kinetic theory, PV diagrams,

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 2018 Season

Thursday April 12, 2018

All schools and areas must finish the April exam and post mark or scan all results by April 30th.

No area may take the April exam during the first week of April or the first week of May

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

What is to be mailed back to our office?

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 2019 Season

Thursday January 10, 2019 Thursday February 14, 2019

Thursday March 14, 2019 Thursday April 11, 2019