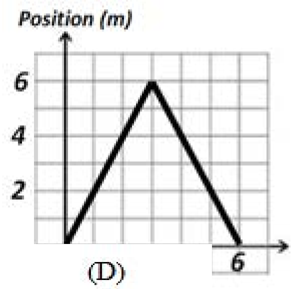
PHYSICS I **<u>Salmon</u>**

JANUARY 11, 2018 Corrections:

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.

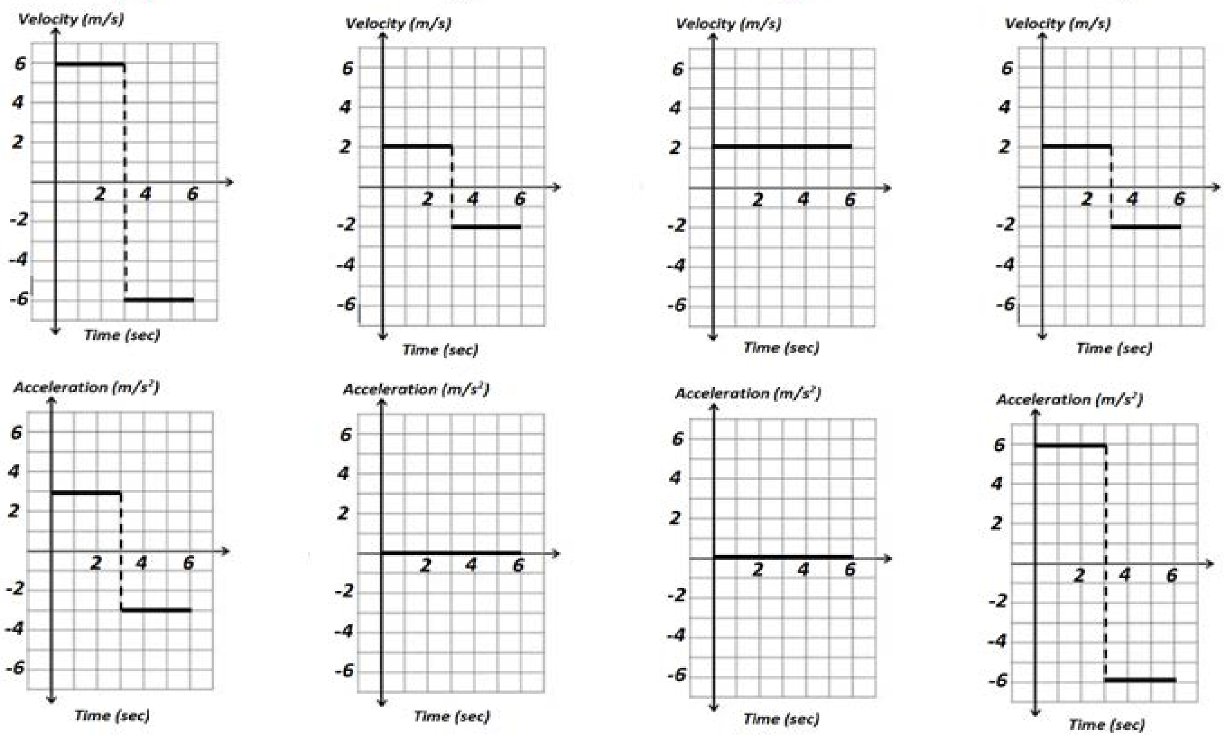
Use:* g = -10 m/s^2 *and the vertically upward direction is positive unless specifically stated otherwise. Ignore air resistance unless specifically stated otherwise.

1. An object moves as represented in the *position/time* graph provided to the right.



Which *pair* of the following graphs of *velocity/time* and *acceleration/time* describe the same object motion within the same time frame? Ans is B

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



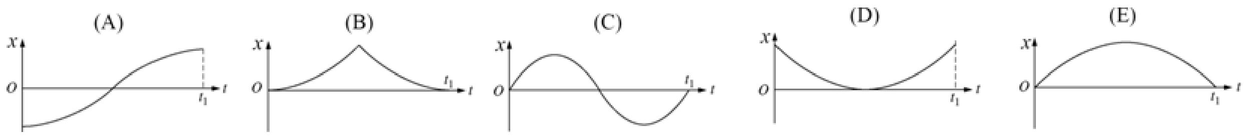
2. You throw a small ball upward and measure the upward distance that it travels to its peak. If you then throw the same ball so that it travels twice the upward distance to its peak, what is true about the motion of the ball the second time it is thrown upward?

(A) Its initial speed was twice the speed in the first experiment.
(B) Its initial speed was less than twice the speed in the first experiment.
(C) Its initial speed was more than twice, but less than four times the speed in the first experiment.
(D) Its initial speed was four times the speed in the first experiment.
(E) Its initial speed was more than four times the speed in the first experiment.

3. A ball is dropped off of a cliff of height *h*. Its velocity upon hitting the ground is *v*. At what height from the bottom of the cliff is the ball's velocity equal to *v*/2?

(A) *h*/16 (B) *h*/4 (C) *h*/2 (D) 3*h*/4 (E) 15*h*/16

4. A bungee jumper drops from rest off of a bridge, and is in freefall for half of the distance to the ground. Her cable then kicks in, and she slows down at a constant acceleration for the other half of the distance. Which of the following graphs could represent her position as a function of time? Ans is A



5. At the beginning of a basketball game, the referee tosses the ball straight upward between two players. At what speed must a basketball player leave the floor in an attempt to grab the ball if his center of gravity must achieve a height of 1.25 m above the floor?

(A) $1.25 m/s$ (B) $2.5 m/s$ (C) $5 m/s$ (D) $25 m/s$

6. A student gives a horizontal shove to an old, rusty shopping cart. The shopping cart squeaks to a halt within seconds. Which of the following slows down the shopping cart?

(A) The normal force exerted by the wheels on the axles.
(B) The friction force exerted by the wheels on the axles.
(C) The normal force exerted by the ground on the wheels.
(D) The friction force exerted by the ground on the wheels.

7. A powerful motorcycle can produce an acceleration of $4 m/s^2$ while already traveling at a speed of $90 km/hr$.
At this speed, the net resisting force (including air and friction) is 400-N. What is the magnitude of the force the motorcycle applies to the road in order to accomplish this acceleration, if the motorcycle and rider have a combined mass of 320-kg?

(A) $1080N$ (B) $1280N$ (C) $1480N$ (D) $1680N$

8. Consider the four descriptions of an object below:

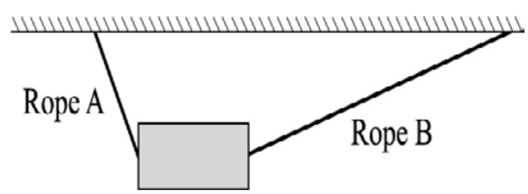
I. An object experiences uniform velocity in a straight line path.
II. An object rests motionless on a tabletop.
III. An object slides down an inclined ramp at constant speed.
IV. An object moves at a constant speed in a circular path.

Which of the above is a description of an object in equilibrium?

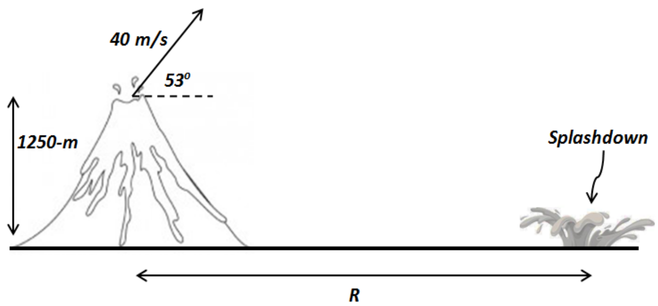
(A) *I & II* only (B) *II* only (C) *I, III,* & *IV* only (D) *I, II,* & *III* only

9. A block hangs from two ropes at unequal angles, as shown above. The block is at rest. Which of the following makes correct comparisons of the tension in each rope?

(A) The tension is greater in rope A.
(B) The tension is greater in rope B.
(C) The tension is equal in both ropes.
(D) The mass of the block must be known.
(E) The exact angles of the ropes must be known.



Use the following information for Questions #10 & 11.
Kilauea is an active shield volcano on the "big" island of Hawaii. It has been constantly erupting lava and spitting rocks since 1983, adding over 600 acres of new land via cooling lava. Kilauea rises 1250-m above the Pacific Ocean. As shown below, a volcanic rock is ejected from the center of the crater at a velocity of $40 \, m/s$ at an angle of 53^o above horizontal. Use $\sin 53^o = 0.8$ and $\cos 53^o = 0.6$.



10. What is the maximum height above the Pacific Ocean this volcanic rock reaches?
(A) $1024m$ (B) $1250m$ (C) $1301m$ (D) $2274m$

11. At what horizontal distance, ***R***, from the center of the crater does it splash into the ocean? Correct ans is B
(A) $386m$ (B) $464m$ MG (C) $515m$ ~~(D) 618m~~

Use the following information for Questions #12 - # 14. An elevator containing physics students has a total mass of 2000-kg (mass of empty elevator PLUS students…). The elevator begins at rest on the ground floor and ends at rest on the top floor of a physics building.

12. The elevator accelerates upward from rest at a rate of $1.5 \, m/s^2$ for $2\sec$. Calculate the tension in the elevator cable during this upward acceleration.
(A) $23{,}000N$ (B) $20{,}000N$ (C) $17{,}000N$ (D) $3{,}000N$

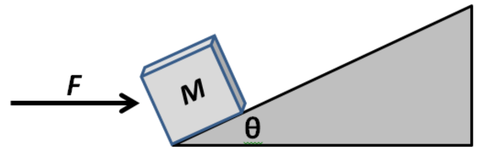
13. After this brief acceleration, the elevator continues upward at a constant velocity for nine seconds. It then decelerates at a rate of $3 \, m/s^2$ and stops. Calculate the tension in the elevator cable during this deceleration.
(A) $6{,}000N$ (B) $14{,}000N$ (C) $20{,}000N$ (D) $26{,}000N$

14. Assuming the ground floor is $y = 0$, what is the final vertical position of the elevator full of students?
(A) $8m$ (B) $27m$ (C) $31.5m$ (D) $39.5m$

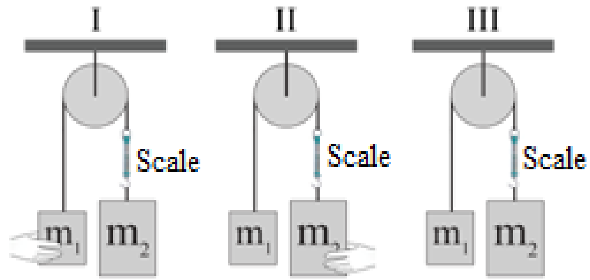
15. Suppose you want to push a crate of mass ***M*** up a frictionless ramp inclined at angle ***θ***, as shown below. To do so, you apply a totally horizontal force ***F*** and cause the crate to slide upward to the top at a constant speed. What is the magnitude of ***F*** if the crate moves at a constant speed up the ramp, assuming ***F*** remains horizontal the entire trip? Correct Ans is letter A.

(A) $Mg\tan\theta$ (B) $Mg\sin\theta$

(C) $Mg\cos\theta$ ~~(D) Mg~~$\dfrac{\cos\theta}{\sin\theta}$

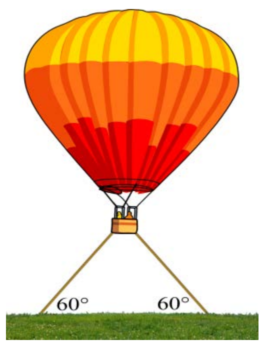


16. In the scenarios shown below, two blocks of masses m_1 and m_2, whereas $m_2 > m_1$, are connected by a massless string over a light, frictionless pulley. In scenario I a hand is holding block 1 so that it stays at rest, in scenario II a hand is holding block 2 so that it stays at rest, and in scenario III the blocks are released from rest. What comparison can you make about the scale readings in each of the three scenarios?



(A) The scale reading in scenario I is the greatest, followed by scenario II, and then scenario III.
(B) The scale reading in scenario I is the greatest, followed by scenario III, and then scenario II.
(C) The scale readings in scenarios I and II are equal, and each is greater than scenario III.
(D) The scale readings in scenarios I and II are equal, and each is less than scenario III.
(E) The scale readings in all three are equal.

17. A 350 kg hot air balloon feels a 5,000 N upward buoyant force from the air. The balloon is tethered to the ground by two ropes that are oriented at angles 60° from the horizontal, as shown below. How much tension must each rope be able to withstand in order for the balloon not to be lifted off the ground?

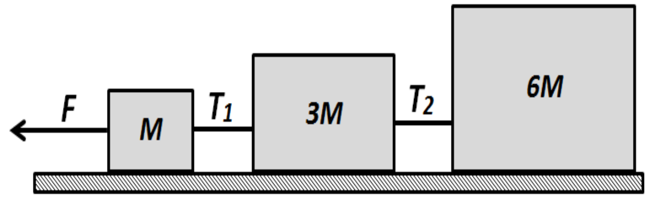


(A) 785 N (B) 900 N (C) 1,570 N (D) 2,900 N (E) 4,870 N

Use the following information for Questions #18 & #19. As shown, three boxes of masses, $\boldsymbol{M}$, $3\boldsymbol{M}$, and $6\boldsymbol{M}$ respectively, are pulled along a frictionless surface by a single horizontal force $\boldsymbol{F}$.

18. What is the acceleration of the $3\boldsymbol{M}$ mass?

(A) $\dfrac{F}{2M}$ (B) $\dfrac{F}{3M}$ (C) $\dfrac{F}{4M}$ (D) $\dfrac{F}{10M}$



19. What is the ratio of the tensions in the two ropes between the boxes, T_1/T_2 ?

(A) $1/10$ (B) $1/4$ (C) $2/3$ (D) $3/2$

Use the following information for Questions #20 & #21. A 3-kg physics textbook sits on your flat level passenger seat as you drive to school. You exit the highway at a speed of $10\,m/s$ onto a level circular ramp of radius 50-m. You maintain a constant $10\,m/s$ speed around the ramp.

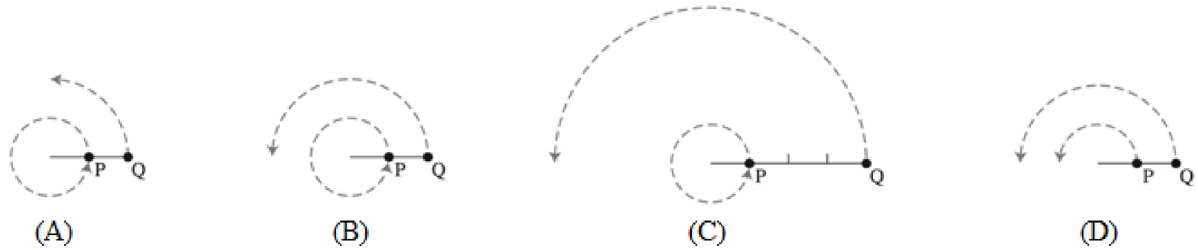
20. What is the smallest coefficient of static friction between the textbook and the seat so that the book does not slide while you proceed along the level ramp?

(A) 0.1 (B) 0.2 (C) 0.3 (D) 0.4

21. If there is no friction between the textbook and the seat and the ramp is actually banked downward to the right (as you drive) at an angle of 15^{o} below horizontal, what is the fastest speed you can negotiate the curve and have the textbook not slide?

(A) $8\,m/s$ (B) $10\,m/s$ (C) $11.6\,m/s$ (D) $22\,m/s$

Questions 22-24 relate to the following four scenarios, in which object P and Q each move along the dotted lines shown at constant speeds, during the same time interval. In drawing letter A the distance from the center of the circle to P is r, while the distance to Q is 2 r. In letter C Q is 4 r, while in letter D Q is again 2 r.



22. In which scenario are the two objects moving at equal speeds?

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

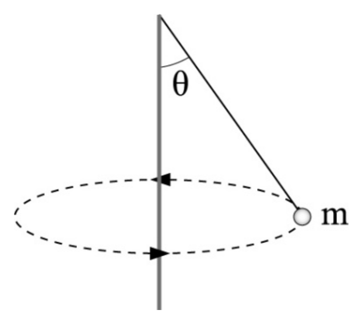
23. In which scenario do the two objects have the same magnitude of acceleration?

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

24. In which scenario is the acceleration of object Q twice that of object P?

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

25. The conical pendulum shown below swings in a circle of radius 0.6 m and speed 1.4 m/s. What angle does the string make with the vertical?



(A) 5°

(B) 18°

(C) 26°

(D) 34°

(E) Cannot determine the angle since the mass of the pendulum must be known

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 I **Salmon Exam**

JANUARY 11, 2018

SOLUTIONS Corrections:

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

January Exam:
Kinematic, Dynamics, Circular Motion, Universal Gravitation.
February Exam:
impulse and linear momentum and conservation of linear momentum: collisions, Work and Energy, Conservation of Energy, Collisions, Plus review of Jan topics
March Exam:
Rotational kinematics, torque, rotational dynamics Conservation of angular momentum, Simple Harmonic motion: simple pendulum, Mass-spring systems Plus review of Jan and Feb topics
April Exam:
Introductory electrostatics: Concepts of electric charge Conservation of electric charge, Coulomb's Law, DC circuits (resistors only) Mechanical waves and sound, Plus review of 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 28th, 2018

New Jersey Science League
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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 for 2019 Season

Thursday January 10, 2019 Thursday February 7, 2019
Thursday March 7, 2019 Thursday April 11, 2019

PHYSICS I Salmon Corrections
FEBRUARY 8, 2018

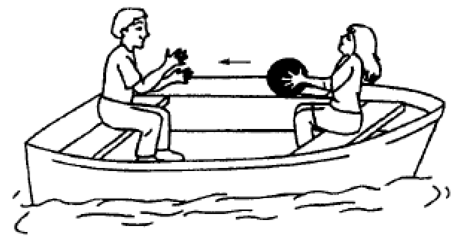
Directions: For each question or statement fill in the appropriate space on the answer sheet. Use the letter preceding the word, phrase, or quantity which best completes or answers the question. Each of the 25 questions is worth 4 points.
Use: $g = -10\ m/s^2$ and the vertically upward direction is positive unless specifically stated otherwise.
Ignore air resistance unless specifically stated otherwise.

1. Which of the following is an acceptable unit for impulse using fundamental MKS units?

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

2. As shown below, two people sit at opposite ends of a boat, which is initially at rest. The person to the right throws a large ball to the person on the left. What is the direction of the velocity of the people/boat system at the time immediately after the ball is thrown and, later, after the ball is caught? (Assume that air and water friction are negligible.)

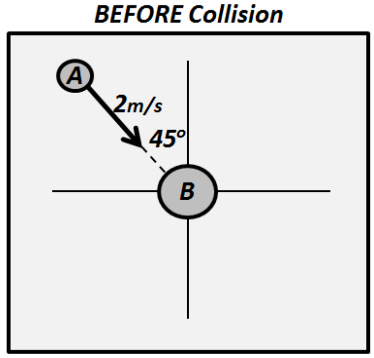
	Immediately After the Ball is Thrown	After the Ball is Caught
(A)	Right	At rest
(B)	Left	At rest
(C)	At rest	At rest
(D)	Right	Left
(E)	Left	Right



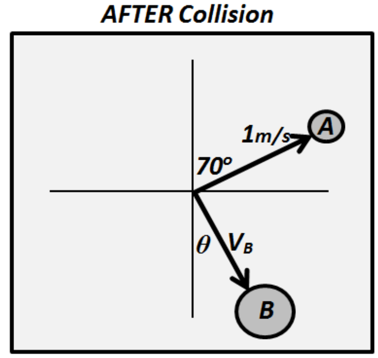
3. As shown in an overhead view below, a small disc, ***A***, strikes a larger disc, ***B***, on a frictionless air table. The $0.25kg$ ***Disc A*** is moving at a velocity of $2\,{}^{m}/_{s}$ at 45^o before the collision with the stationary $0.5kg$ ***Disc B***. After the collision, ***Disc A*** is seen moving at 70^o to the right of vertical at a speed of $1\,{}^{m}/_{s}$. What is the magnitude and direction, V_B and θ, respectively, of the velocity of ***Disc B*** after the collision?

	V_B	θ
(A)	$0.46\,{}^{m}/_{s}$	75^o
(B)	$0.91\,{}^{m}/_{s}$	75^o
(C)	$0.46\,{}^{m}/_{s}$	15^o
(D)	$0.91\,{}^{m}/_{s}$	15^o

BEFORE Collision



AFTER Collision



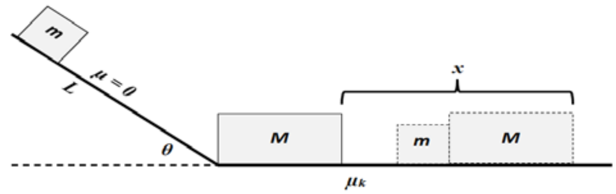
4. A bobsled of mass M moves without across a surface with negligible friction at speed v. Two objects are dropped vertically into the bobsled one after the other: first an object of mass $2m$, and then an object of mass m. Afterward the sled moves with speed $v/2$. What would be the final speed of the sled if the objects were dropped into it at the same time?

(A) $v/4$ (B) $2v/3$ (C) $v/3$ (D) $v/2$ (E) $3v/5$

5. A cliff diver of mass $55kg$ runs toward the edge of a cliff and jumps at $6\,{}^{m}/_{s}$ at an angle of 30^o above horizontal. The cliff edge is $40m$ above the water below. How fast will this diver be moving when she hits the water?

(A) $10\,{}^{m}/_{s}$ (B) $15\,{}^{m}/_{s}$ (C) $21\,{}^{m}/_{s}$ (D) $29\,{}^{m}/_{s}$

Use the following information for Questions #6 - #8: As shown below, a small box of mass ***m*** slides without friction down a straight ramp of length ***L*** inclined at an angle of ***θ*** above the horizontal. Upon reaching the bottom of the ramp it strikes and sticks to a larger stationary box of mass ***M***. The two boxes then slide along a rough horizontal floor until coming to rest at a distance ***x*** from the bottom of the ramp.



6. What is the speed at which the small box reaches the bottom of the ramp, v_m ?

(A) $\sqrt{\frac{2gL}{\cos\theta}}$ (B) $\sqrt{\frac{2gL}{\sin\theta}}$

(C) $\sqrt{2gL\sin\theta}$ (D) $\sqrt{2gL\cos\theta}$

7. Immediately after sticking to the larger box, with what speed, V_T , do both boxes move? Use the symbol v_m (asked for in #6) for the speed of the small box at the end of the ramp.

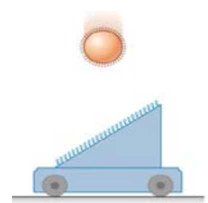
(A) $\frac{Mv_m}{M+m}$ (B) $\frac{mv_m}{M+m}$ (C) $\frac{(M+m)v_m}{M}$ (D) $\frac{(M+m)v_m}{m}$

8. Using V_T (asked for in #7) for the initial speed of both boxes, what is distance ***x***?

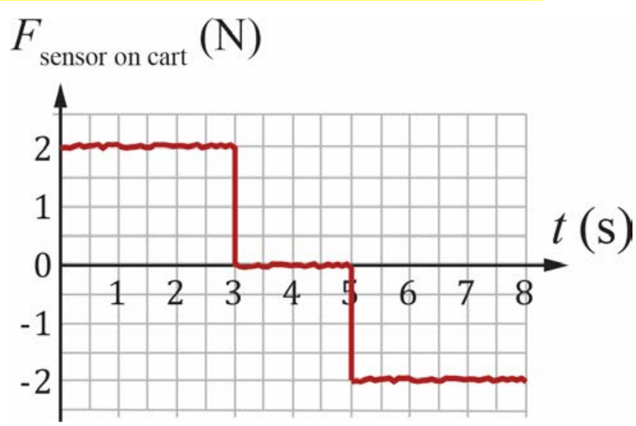
(A) $\frac{2\mu_K V_T^2}{g}$ (B) $\frac{2V_T^2}{\mu_K g}$ (C) $\frac{\mu_K V_T^2}{2g}$ (D) $\frac{V_T^2}{2\mu_K g}$

9. You have two objects: a ball that is covered with the hook side of Velcro and an incline covered with the loop side of Velcro that is fixed onto a low-friction cart. The ball is dropped vertically onto the incline, which is at rest. When the ball collides with the incline, it sticks to it without moving relative to the surface. Which of the following will be true about the cart/ball system after the ball sticks to the cart?

(A) It will be rolling to the left.
(B) It will be rolling to the right.
(C) It will be at rest.
(D) The final velocity of the system depends on the angle of the incline.



10. A cart of mass *m* is at rest on a horizontal, frictionless track in a laboratory. A student uses a force sensor to exert horizontal force on the cart, and collects the data shown in the graph below. Which of the following is true about the cart during the time interval 0-8s? All full credit: Graph was missing.

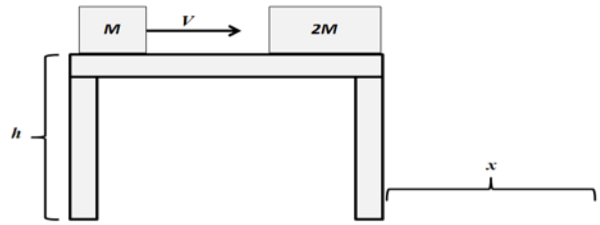


(A) Its initial momentum is positive, and its final momentum is negative.
(B) Its initial momentum is in the opposite direction as its final momentum.
(C) Its momentum is zero at *t* = 4 s.
(D) Its initial momentum is equal to its final momentum.

11. Two identical balls with equal speed hit a wall. Ball 1 hits the wall and stops. Ball 2 bounces off with half of its initial speed in the opposite direction. Which of the following is true?

(A) Ball 2 has half times as much impulse exerted on it as Ball 1.
(B) Ball 2 has twice as much impulse exerted on it as Ball 1.
(C) Ball 2 has 3/2 as much impulse exerted on it as Ball 1.
(D) Ball 2 has 2/3 as much impulse exerted on it as Ball 1.
(E) Ball 2 has the same impulse exerted on it as Ball 1.

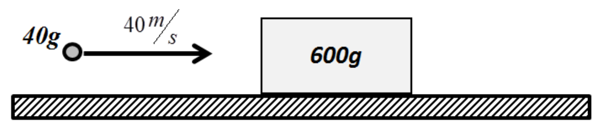
12. As shown below, a mass ***M*** slides without friction at speed ***V*** on a smooth lab tabletop. It strikes a larger mass 2***M*** and sticks to it. At what horizontal distance ***x*** from the edge of the table do the masses strike the floor?



(A) $\frac{V}{3}\sqrt{\frac{2h}{g}}$ (B) $\frac{V}{\sqrt{3}}\sqrt{\frac{2h}{g}}$

(C) $V\sqrt{\frac{2h}{3g}}$ (D) $V\sqrt{\frac{2h}{g}}$

13. A 40-gram $(40g)$ steel pellet moving at $40 {}^{m}\!/\!{}_{s}$ hits and embeds $10cm$ into a $600g$ block of wax. Assuming the wax offers a constant resisting force to the pellet until the pellet reaches the $10cm$ inside the wax, what is the ratio of the initial kinetic energy of the system (before collision) to the final kinetic energy of the system (after collision), $\frac{K_i}{K_f}$?



(A) $32/1$ (B) $16/1$

(C) $8/1$ (D) $1/1$

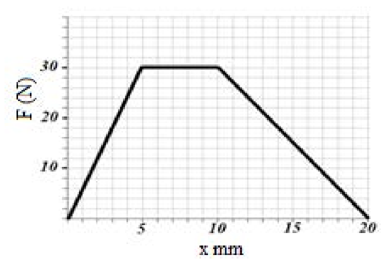
14. The graph shown below represents a variable force ***F*** measured in Newtons acting on a $3kg$ object through a displacement ***x*** measured in millimeters. If the object starts at rest, what is its final speed when it reaches $20mm$?

(A) $0.25 {}^{m}\!/\!{}_{s}$

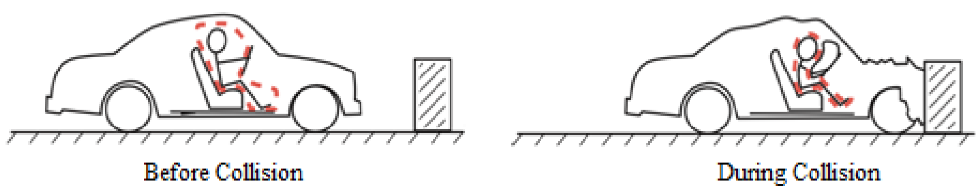
(B) $0.5 {}^{m}\!/\!{}_{s}$

(C) $0.75 {}^{m}\!/\!{}_{s}$

(D) $1.0 {}^{m}\!/\!{}_{s}$



15. During a head-on collision, how does an air bag protect a passenger in the car?

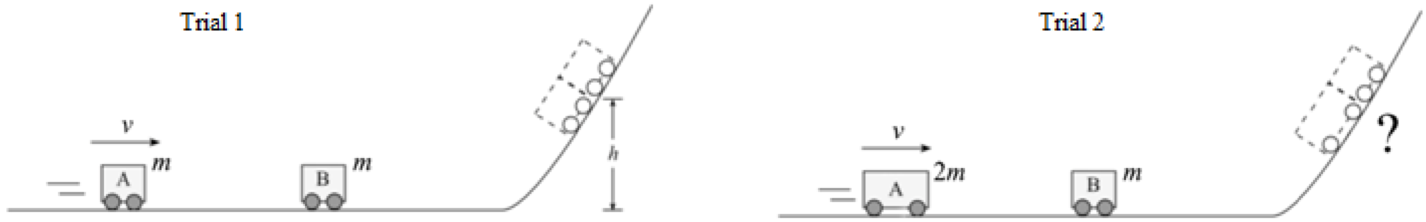


(A) It decreases the impulse exerted the passenger.
(B) It decreases the initial momentum of the passenger.
(C) It lengthens the stopping time of the passenger, and decreases the force exerted on them during the collision.
(D) It shortens the stopping time of the passenger, and increases the force exerted on them during the collision.

16. A ball of mass *m* with speed *v* strikes the floor at an angle θ with the normal, as shown above. It then rebounds with the same speed and at the same angle. The magnitude of the ball's change in kinetic energy is Even though the diagram is missing it is not needed in order to answer this question. KE is dependent on mass and velocity. Neither changes so answer remains as letter A.

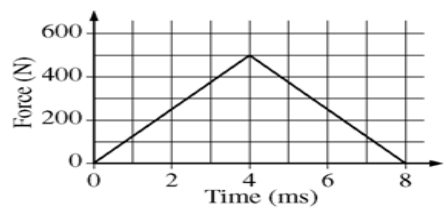
(A) Zero (B) $\frac{1}{2}m(v\cos\theta)^2$ (C) $\frac{1}{2}mv^2\cos\theta$ (D) $\frac{1}{2}m(2v\cos\theta)^2$ (E) $2mv^2\cos\theta$

17. In Trial 1 shown below, Cart A of mass *m* is collided with identical Cart B on a flat frictionless surface. The two carts stick together, and travel up a frictionless incline to reach a maximum vertical height *h* above the flat track. Trial 2 is identical to Trial 1, except the mass of Cart A is changed to 2*m*. To what maximum vertical height will the two carts travel in Trial 2, in terms of *h*? (Height of the carts refers to the height of their combined center of mass) No answer is correct. All full credit



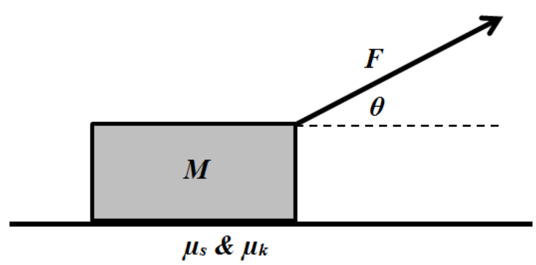
(A) h (B) $\sqrt{2}h$ (C) $2h$ (D) $4h$ (E) Less than h

18. A 0.050 kg tennis ball is moving to the left at 10 m/s when it is hit by a tennis racket that is moving to the right. The magnitude of the force exerted on the ball by the racket as a function of time is shown in the figure below. What is the speed of the ball after the collision with the racket?



(A) 30 m/s (B) 50 m/s (C) 70 m/s (D) 90 m/s

Use the following information for Questions #19 - #21: As shown, a force ***F*** is directed upward at an angle ***θ*** by a rope in an attempt to move a heavy crate of mass ***M*** across a rough floor. Coefficients of static and kinetic friction are μ_s & μ_k, respectively.



19. What minimum force ***F*** is required to get the mass to move if initially at rest?

(A) $\dfrac{\mu_s Mg}{\cos\theta + \mu_s \sin\theta}$ (B) $\dfrac{\mu_s Mg}{\sin\theta + \mu_s \cos\theta}$

(C) $\dfrac{\mu_k Mg}{\cos\theta + \mu_k \sin\theta}$ (D) $\dfrac{\mu_k Mg}{\sin\theta + \mu_k \cos\theta}$

20. What minimum force ***F*** is then required to keep it moving at a constant speed once it is moving?

(A) $\dfrac{\mu_s Mg}{\cos\theta + \mu_s \sin\theta}$ (B) $\dfrac{\mu_s Mg}{\sin\theta + \mu_s \cos\theta}$ (C) $\dfrac{\mu_k Mg}{\cos\theta + \mu_k \sin\theta}$ (D) $\dfrac{\mu_k Mg}{\sin\theta + \mu_k \cos\theta}$

21. After the mass has been moving at a constant speed ***v*** for a short distance, the rope breaks. Through what distance does the mass move before coming to rest?

(A) $\dfrac{v^2}{g(\cos\theta + \mu_s \sin\theta)}$ (B) $\dfrac{v^2}{\mu_s g}$ (C) $\dfrac{v^2}{\mu_k g}$ (D) $\dfrac{v^2}{2\mu_k g}$

Use the following information for Questions #22 - #24: To escape Lego™ Joker, Lego™ Batman shoots a grappling hook vertically upward from his Lego™ utility belt to the Lego™ Batcopter operated by Lego™ Robin, as shown below. Lego™ Batman's grappling hook cable is pulled by a small battery-powered motor that lifts the $250\,gram$ Lego™ Batman to a height of h at a constant speed of $5\,{}^{m}\!/_{s}$. The battery that powers Lego™ Batman's grappling hook motor stores $10J$ of energy. Assume the motor is 100% efficient.

22. How much power is delivered to the motor?

(A) $1.25W$ (B) $12.5W$
(C) $125W$ (D) $1250W$

23. To what height does Lego™ Batman rise above the ground if all the stored battery energy is converted? Ans is C not B

(A) $1m$ ~~(B) 2m~~
(C) $4m$ (D) $5m$

24. If the Lego™ Batcopter were moving horizontally at $20\,{}^{m}\!/_{s}$ Just before Lego™ Batman grabbed onto it and it continued in a purely horizontal path, what is its new horizontal speed? All full credit since mass of Batcopter (1 Kg) was left out.

(A) $20\,{}^{m}\!/_{s}$ (B) $18\,{}^{m}\!/_{s}$ (C) $16\,{}^{m}\!/_{s}$ (D) $14\,{}^{m}\!/_{s}$

25. A 1,500 kg car traveling at 12.5 m/s collides with a 2,500 kg van stopped at a traffic light. As a result of the collision, the two vehicles become attached. If the duration of the collision is 0.2 seconds, which choice is closest to the magnitude of the average force exerted on the car during this time?

(A) 5 kN (B) 35 kN (C) 45 kN (D) 60 kN (E) 95 kN

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

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

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

$\Delta U_E = q\Delta V$

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

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

$V = IR$

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

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

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

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

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

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

$C = Q/\Delta V$

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

$C_{parallel} = \Sigma C_i$

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

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
ρ = momentum
λ = wavelength
ϕ = work function

PHYSICS I **Salmon Exam** **Corrections**

FEBRUARY 8, 2018

SOLUTIONS

1. B	14. B
2. A	15. C
3. D	16. A
4. D	17. ~~C~~ All full credit No correct Ans
5. D	18. A
6. C	19. A
7. B	20. C
8. D	21. D
9. C	22. B
10. D All full credit: Missing graph	23. ~~B~~ C
11. C	24. C All full credit: 1 kg left out
12. A	25. D
13. B	

January Exam: Kinematic, Dynamics, Circular Motion, Universal Gravitation.
February Exam: impulse and linear momentum and conservation of linear momentum: collisions, Work and Energy, Conservation of Energy, Collisions, Plus review of Jan topics
March Exam:
Rotational kinematics, torque, rotational dynamics Conservation of angular momentum, Simple Harmonic motion: simple pendulum, Mass-spring systems Plus review of Jan and Feb topics
April Exam:
Introductory electrostatics: Concepts of electric charge Conservation of electric charge, Coulomb's Law, DC circuits (resistors only) Mechanical waves and sound, Plus review of 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 28th, 2018

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 for 2019 Season

Thursday January 10, 2019 Thursday February 7, 2019
Thursday March 7, 2019 Thursday April 11, 2019

New Jersey Science League **Salmon Exam No Corrections**

PHYSICS 1

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. As prescribed by the College Board for AP Physics, the work done *on* a system is a *positive* quantity.
***Use: g =10 m/s²*.**

ADDITIONAL INFORMATION: *All axes of rotation are taken to be at the center of mass unless specifically stated otherwise*.

Rotational Inertia of a *solid disc*: $\frac{1}{2}MR^2$

Rotational Inertia of a *hollow disc* (hoop or ring): MR^2

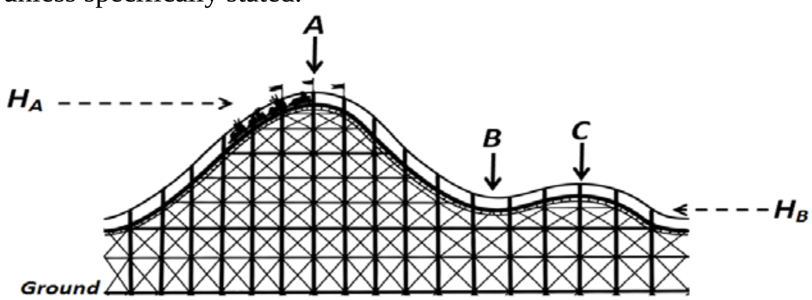
Rotational Inertia of a *solid sphere*: $\frac{2}{5}MR^2$

Rotational Inertia of a *hollow sphere*: $\frac{2}{3}MR^2$

Rotational Inertia of a *solid rod of length L with axis of rotation through the geometric center*: $\frac{1}{12}ML^2$

Rotational Inertia of a *solid rod of length L with axis of rotation through one end*: $\frac{1}{3}ML^2$

Use the following information for Questions #1 & #2: Shown below is the old-style wooden roller coaster called *El Toro* at *Six Flags Great Adventure* in Jackson, NJ. An occupied roller coaster of total mass ***M*** is pulled to the top of the first hill, labelled as ***Point A***, by means of a motor. It is then sent on its merry way to travel through ***Points B*** and ***C***. At ***Point A***, just before its descent, the coaster is travelling at an initial speed of V_A. ***Point A*** is at a height of H_A above the ground below. ***Point B*** is at a height of H_B above the ground below. Once the car reaches ***Point A***, the only force of "propulsion" is gravity. Neglect friction unless specifically stated.



1. Which expression below represents the speed of the coaster car when it reaches ***Point B***?

(A) $\sqrt{MV_A^2 + 2Mg\left(H_A - H_B\right)}$

(B) $\sqrt{V_A^2 + 2g\left(H_A - H_B\right)}$

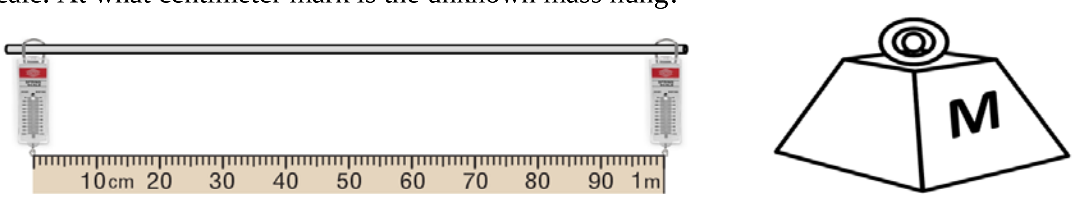
(C) $\sqrt{V_A^2 + 2Mg\left(H_A - H_B\right)}$

(D) $\sqrt{V_A^2 - 2g\left(H_A - H_B\right)}$

2. At which point(s) along the path is the normal force exerted by the tracks on the roller coaster car the greatest?

(A) ***Point A*** (B) ***Point B*** (C) ***Points A*** & ***C*** (D) ***Point C***

3. As shown below, a spring scale is attached to each end of a uniform meter stick and suspended from a solid metal bar. An unknown mass, ***M***, much larger than the mass of the meter stick (making the mass of the meter stick negligible) is hung from a point on the meter stick. The result is that the spring scale on the right has a reading that is three times that of the left spring scale. At what centimeter mark is the unknown mass hung?



(A) 20 cm (B) 80 cm (C) 25 cm (D) 75 cm

4. “Walking the plank” is seen once in a while in Hollywood pirate movies. It usually entails simply laying a long wooden board near the edge of the ship so that some of it is suspended over usually shark-infested waters then some poor soul must “walk” it to his demise. In the image below, the sailor, not named *Captain Jack Sparrow*, “walking” has a mass of 75-kg. The plank is of uniform density and width and is 10-m long with 2-m of length hanging over the water and 8-m still inside the ship. The plank weighs 200 Newtons. How far out from the edge of the boat will this poor sailor be able to walk before the plank begins to tip toward the water below?

(A) 0.4-m (B) 0.6-m

(C) 0.8-m (D) 1.0-m

5. After a particularly grueling and muddy mountain bike ride, you place your bicycle upside-down on a shop bench to clean and align it (***Figure 1***). You notice five large blobs of dried mud stuck to the outside of the front tire and no matter how you turn the wheel or how fast you spin it, the tire keeps coming to rest in the position shown in ***Figure 2***; indicating rotational and static equilibrium. There are two clumps with mass ***M***, one clump of mass 2***M*** and one clump of mass 3***M***. What is the mass of the 5^{th} mud clump, designated with a smiley-face and a lower-case ***m***, in terms of ***M***?

(A) $\frac{M}{2}$

(B) M

(C) $\frac{3M}{2}$

(D) $2M$

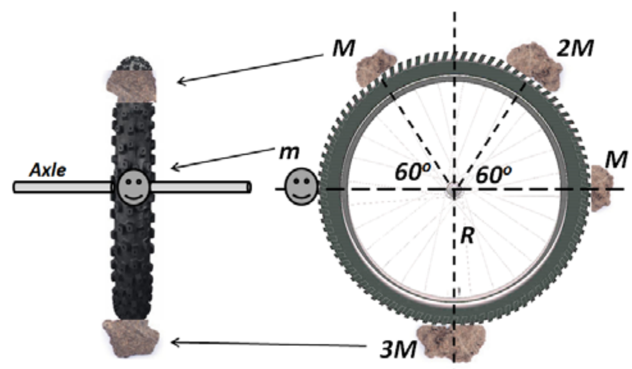
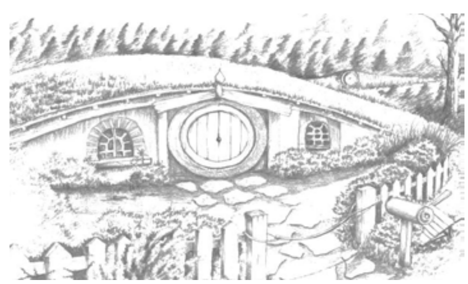


Figure 1 Figure 2

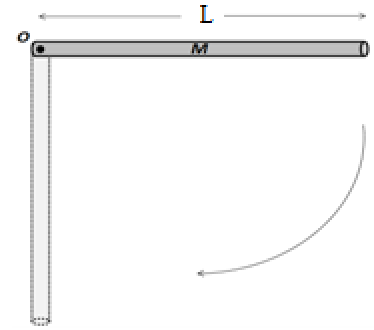
6. Below is an original pencil sketch of a Hobbit’s home in Hobbiton, The Shire, from JRR Tolkien’s *Lord of the Rings* Trilogy™. The doors to the Hobbits’ homes are circular; impractical, but cute. Note the doorknob on these Hobbit doors is located in the center of the circular door. With what minimum force must the occupant, Bilbo Baggins, push on this central doorknob to open it compared to the minimum force necessary, ***F***, if the knob were placed at the more modern and conventional position at the far left edge of the door. Assume the door swings inward to the right; hinges on the right of the door as seen from the image.

(A) $\frac{F}{2}$ (B) F

(C) $\frac{3F}{2}$ (D) $2F$



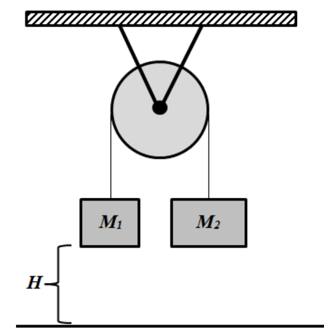
7. A uniform long thin solid rod of length ***L*** and mass ***M*** is free to rotate on a frictionless axle located at the left end at point ***O***, as shown below. The rod is released from rest from the initial horizontal position. Which of the following choices represents the angular speed of the rod when it reaches the vertical position?



(A) $\sqrt{\frac{g}{3L}}$ (C) $\sqrt{\frac{6g}{L}}$

(B) $\sqrt{\frac{3g}{L}}$ D) $\sqrt{\frac{g}{6L}}$

8. In the diagram below, two masses are suspended motionless from the same height, $H = 2m$, from a massless frictionless pulley. $M_1 = 2kg$ and $M_2 = 4kg$. With what speed does M_2 strike the ground after the system is released from rest?



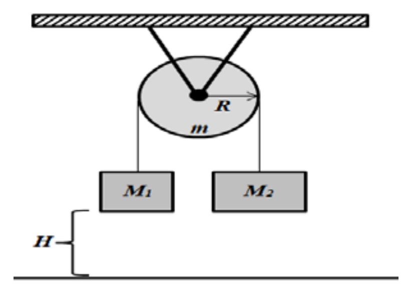
(A) $2.4 \,{}^{m}/_{s}$

(B) $3.2 \,{}^{m}/_{s}$

(C) $3.7 \,{}^{m}/_{s}$

(D) $6.2 \,{}^{m}/_{s}$

9. The frictionless and massless pulley used in #8 is now replaced with one from the semi-real world where it actually has a mass of $m = 4kg$ and a radius of $R = 15cm$. Treat the pulley as a uniform circular disc and assume the string does not slip or stretch and there is still negligible friction. After released from rest, with what speed does M_2 strike the ground? Use the same masses and height as in #8 above.



(A) $2.4 \,{}^{m}/_{s}$

(B) $3.2 \,{}^{m}/_{s}$

(C) $3.7 \,{}^{m}/_{s}$

(D) $6.2 \,{}^{m}/_{s}$

10. A solid metal sphere of mass ***M*** starts at rest and rolls without slipping down an incline. The incline has a length of ***L*** and is inclined at an angle of ***θ*** above the horizontal. Which of the following represents the speed of the center of mass of the sphere upon reaching the bottom of the incline?

(A) $\sqrt{2gL\sin\theta}$ (B) $\sqrt{\frac{5}{7}gL\sin\theta}$ (C) $\sqrt{\frac{10}{7}gL\cos\theta}$ (D) $\sqrt{\frac{10}{7}gL\sin\theta}$

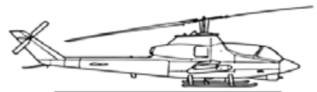
11. Consider the following quantities as an object undergoes a constant centripetal acceleration:

I. Magnitude of tangential velocity *III. Linear Momentum*
II. Direction of tangential velocity *IV. Angular Momentum*

Which of the above quantities *changes* as long as the radius remains constant?

(A) I & III only (B) III & IV only (C) II & III only (D) All of them; I, II, III, & IV

12. Consider the below images of a typical helicopter with a single rotor and a tail "fan" and a large military Chinook helicopter with two large rotors and no tail fan. It is noted that the two rotors of the Chinook helicopter rotate in opposite directions. Why must the two rotors on the Chinook rotate in opposite directions?



"Typical" helicopter with *ONE* rotor and a tail fan.

"Chinook" helicopter with *TWO* rotors and *NO* tail fan.

(A) If both blades rotated in the same direction, the "lift" force each creates would interfere with the other through turbulent air flow.
(B) If both blades rotated in the same direction, it would violate Newton's Third Law of Motion.
(C) The opposite rotations cause a cancellation of the net energy production of the system; one blade creating a "positive energy, the other an equal and opposite "negative" energy.
(D) The opposite rotations cause a cancellation of the angular momentum of the system; one blade creating a "positive angular momentum, the other an equal and opposite "negative" angular momentum.

13. Fishermen use a suspended spring scale to weigh their catches, although some don't feel obligated to tell the truth about the data. What is the spring constant for such a scale if the spring stretches 8-cm for a 10-kg fish?

(A) $1250\,{}^{N}\!/_{m}$ (B) $800\,{}^{N}\!/_{m}$ (C) $80\,{}^{N}\!/_{m}$ (D) $8\,{}^{N}\!/_{m}$

14. A simple pendulum and a mass on the end of a spring will both oscillate with the same period ***T*** when here on Earth. They are both taken to a "Super-Earth" in a near-by solar system where the planet has twice the radius and twice the mass of Earth. What is the relationship between the original Earth period T and the new period on the Super-Earth?
(A) They both have longer periods
(B) They both have shorter periods
(C) The pendulum has a shorter period, but the mass/spring is the same.
(D) The pendulum has a longer period, but the mass/spring is the same.

15. A certain type of "Cuckoo" clock uses a vertical spring with a cute figurine of mass ***M*** attached to the bottom that oscillates up and down in periodic motion with period ***T***. If the spring breaks and is mistakenly replaced by one that has twice the spring constant as the original, what is the period if using the same cute figurine?

(A) $2T$ (B) $\sqrt{2}T$ (C) ${}^{T}\!/_{\sqrt{2}}$ (D) ${}^{T}\!/_{2}$

16. During an emergency stop, a car decelerates at $7\,{}^{m}\!/_{s^2}$. The tires have a $30cm$ radius, an initial angular velocity of $95\,{}^{rad}\!/_{s}$, and assume they do not slip. How far does the car travel before coming to a stop?

(A) $23.3m$ (B) $58m$ (C) $116m$ (D) $193.4m$

17. A solid disc of mass ***M*** and radius ***R*** rolls without slipping down a ramp of length ***L*** inclined at an angle of θ above the horizontal. It starts at rest and reaches a final linear speed of V at the bottom of the ramp. Which of the following changes could be associated with another solid disc / ramp set-up that would yield a final linear velocity of $2V$?
(A) Keep the same disc, but double the length of the ramp to $2L$.
(B) Double the radius of the disc to $2R$, keep all other quantities the same.
(C) Double the radius to $2R$ *and* double the mass to $2M$ of the disc, keep all other quantities the same.
(D) Keep the same disc, but quadruple the length of the ramp to $4L$.

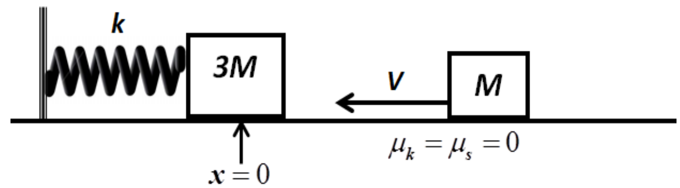
18. A tennis ball of mass $\boldsymbol{M}$ and radius $\boldsymbol{R}$ rolls on level ground without slipping at an initial linear speed of V when it begins ascending a ramp inclined at an angle of θ above the horizontal. Which of the following represents the length of the ramp the ball rolls before coming to a stop? Of course, treat the tennis ball as a hollow sphere.

(A) $\frac{3V^2}{4g\sin\theta}$ (B) $\frac{7V^2}{10g\sin\theta}$ (C) $\frac{5V^2}{6g\sin\theta}$ (D) $\frac{6V^2}{5g\sin\theta}$

19. At recess, three children are sitting on the edge of a merry-go-round that has a mass of $200kg$, has a radius of $2m$, and is spinning at $20RPM$. The kids have masses of $35kg$, $30kg$, and $25kg$. The child whose mass is $30kg$ suddenly jumps off the ride. What is the new angular velocity of the ride in RPM ?

(A) $20RPM$ (B) $22.3RPM$ (C) $23.75RPM$ (D) $25.3RPM$

Use the following information for Questions #20 & #21: As shown below, a mass $\boldsymbol{M}$ is moving to the left on a frictionless horizontal surface at speed $\boldsymbol{V}$ when it collides and sticks to a stationary mass $3\boldsymbol{M}$ which is attached to an ideal spring of spring constant $\boldsymbol{k}$. The left side of the spring is attached firmly to a rigid immovable wall.



20. If $\boldsymbol{M} = 4kg$, $\boldsymbol{V} = 10\,{}^{m}\!/\!_{s}$, and $\boldsymbol{k} = 75\,{}^{N}\!/\!_{m}$, what is the maximum compression of the spring after the collision of $\boldsymbol{M}$ with $3\boldsymbol{M}$?

(A) $\frac{1}{2}m$ (B) $1m$ (C) $2m$ (D) $4m$

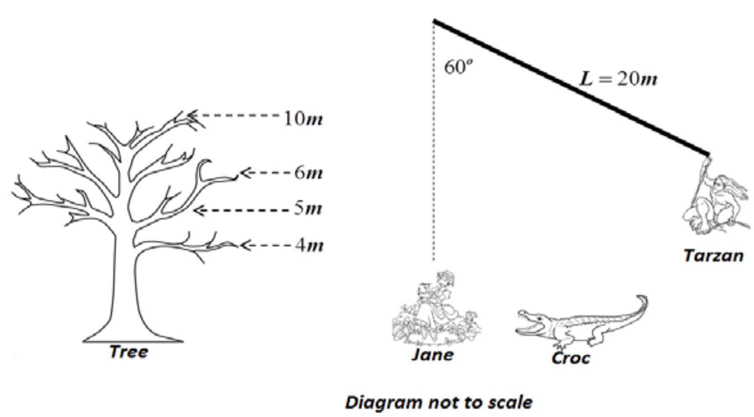
21. What is the ensuing frequency of the system as long as $\boldsymbol{M}$ stays attached to $3\boldsymbol{M}$?

(A) $\frac{5}{4\pi}\sec^{-1}$ (B) $\frac{4}{5\pi}\sec^{-1}$ (C) $\frac{5\pi}{4}\sec^{-1}$ (D) $\frac{4\pi}{5}\sec^{-1}$

22. As shown below, Tarzan is in the process of saving Jane yet again. Jane is reading a book oblivious to the hungry killer crocodile sneaking up on her from behind. Tarzan, of mass $100kg$, starts at rest and swings on a $20m$ long vine that initially is at an angle of 60^o above vertical. He swoops down and grabs Jane, of mass $50kg$, just in time. What is the *maximum* vertical height of the branch they can reach safely on the tree on the left?

(Tarzan and Jane images compliments of Walt Disney clipart: https://www.disneyclips.com)

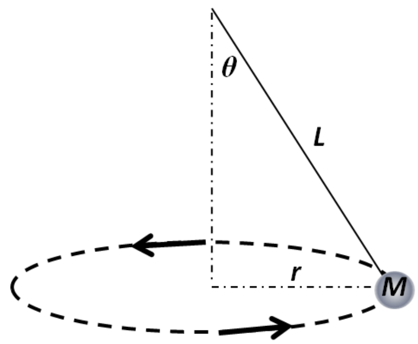
(A) $4m$
(B) $5m$
(C) $6m$
(D) $10m$



23. Betelgeuse, don't say it three times real fast or we're all in trouble, is a red supergiant star in the Orion constellation about 640 light years away from us. It is the 9th brightest star in the night sky. It is so large that if it replaced our own sun the surface of Betelgeuse would be out at Jupiter's orbit! Its mass, M_B, is twenty times the mass of our Sun, $20M_O$, where $M_O = 2x10^{30} kg$. Its radius, R_B, is an astounding $7x10^{11} m$, about 1,000 times the size of our sun! It rotates on its axis with a period, T_B, of $15 yr$. Due to its size and variable radiation output, it is expected to explode in a supernova and create a black hole at any time. If after it undergoes supernova, it collapses into a black hole with a final effective radius R_F, known as the *Schwarzschild Radius*, and keeps 75% of its original mass (the other 25% is ejected into space by the supernova explosion), what is the black hole period of rotation, T_F? Ignore relativistic effects.

(A) $\frac{4R_F^2 T_B}{3R_B^2}$ (B) $\frac{4R_B^2 T_B}{3R_F^2}$ (C) $\frac{3R_B^2 T_B}{4R_F^2}$ (D) $\frac{3R_F^2 T_B}{4R_B^2}$

24. A conical pendulum is a simple pendulum that moves not only back and forth, but moves forward and backwards. This way, the pendulum bob of mass ***M*** sweeps out a circular path in a horizontal plane. The supporting string has a length ***L*** and makes a constant angle of ***θ*** with the vertical. In terms of the variables given and common physical constants, which expression represents the angular momentum of the mass ***M***?



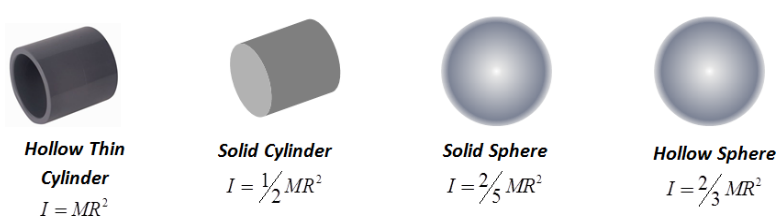
(A) $\sqrt{M^2 g L^3 \sin^3\theta \tan\theta}$

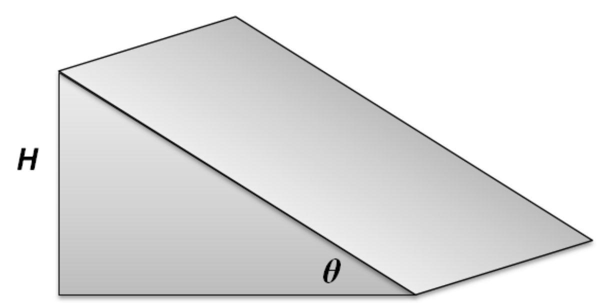
(B) $\sqrt{M^2 g r^3 \sin^3\theta \tan\theta}$

(C) $\sqrt{M^2 g L^3 \sin^2\theta \tan\theta}$

(D) $\sqrt{M^2 g r^3 \sin^2\theta \tan\theta}$

25. Consider the following four objects shown below: a hollow thin cylinder, a solid cylinder, a solid sphere, and a hollow sphere. The rotational inertia is provided, as well as at the beginning of this exam, for each object in reference to the axis that each would use in rolling down an incline. However, *none* of the masses or the radii is known, so you cannot assume they are equal in anything. All four objects are placed at the top of the ramp shown and released from rest. They roll to the bottom without slipping. Without knowing the values of the masses and the radii, in what order do they arrive at the bottom beginning with the "winner"?





(A) Hollow thin cylinder, hollow sphere, solid cylinder, & solid sphere.
(B) Solid sphere, hollow sphere, solid cylinder, & hollow thin cylinder.
(C) Solid sphere, solid cylinder, hollow sphere, & hollow thin cylinder.
(D) This question *cannot be answered* without knowing the masses and radii of each object.

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

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

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

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

$\tau = Fxr = I\alpha$

$I = \Sigma mr^2$

$L = I\omega$

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

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

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

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

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

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

$P = P_o + \rho gh$

$F_b = \rho Vg$

$A_1 v_1 = A_2 v_2$

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

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

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 1 **Salmon Exam** **No Corrections**

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

January Exam:
Kinematic, Dynamics, Circular Motion, Universal Gravitation.

February Exam:
impulse and linear momentum and conservation of linear momentum: collisions, Work and Energy, Conservation of Energy, Collisions, Plus review of Jan topics

March Exam:
Rotational kinematics, torque, rotational dynamics Conservation of angular momentum, Simple Harmonic motion: simple pendulum, Mass-spring systems Plus review of Jan and Feb topics

April Exam:
Introductory electrostatics: Concepts of electric charge Conservation of electric charge, Coulomb's Law, DC circuits (resistors only) Mechanical waves and sound, Plus review of 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 28th, 2018

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 for 2019 Season

Thursday January 10, 2019 Thursday February 7, 2019

Thursday March 7, 2019 Thursday April 11, 2019

PHYSICS 1 Salmon Exam 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*. Use conventional electrical current.

ADDITIONAL INFORMATION:

Fundamental charge: $e = 1.6x10^{-19}C$ Speed of sound in air: $v = 340\,{}^{m}\!/_{s}$

Use the following information for Questions #1 & #2: Before a high school wrestling match, all contestants must weigh-in to be sure they aren't heavier than the weight class they are competing in. The commercial grade scale used by the officials operates on a stiff spring that compresses when the wrestler steps on a platform.

1. If the spring compresses a distance of $1cm$ under its maximum load of $200kg$, what is the effective spring constant?

(A) $2\,{}^{N}\!/_{m}$ (B) $200\,{}^{N}\!/_{m}$ (C) $20,000\,{}^{N}\!/_{m}$ (D) $200,000\,{}^{N}\!/_{m}$

2. At a different school on a different scale, one particular wrestler steps on the scale and the spring, of spring constant $2,900\,{}^{N}\!/_{m}$, compresses a distance of $25cm$, in what weight class listed below is he closest to without being "overweight?" Use $1kg = 2.2\,pounds$.

(A) $152\,pounds$ (B) $160\,pounds$ (C) $170\,pounds$ (D) $182\,pounds$

3. Your jet plane is sitting on the runway at Newark Liberty Airport waiting for take-off for a Spring Break 2018 getaway. Being the physics prodigy you are, you notice the twin jets making a beat frequency of $0.5Hz$ and you are told the average frequency coming from the two jet engines is $4500Hz.$ Which entry in the table below represents the individual frequencies of the two engines?

	Engine #1	***Engine #2***
(A)	$4500Hz.$	$4500Hz.$
(B)	$4499.5Hz.$	$4500.5Hz.$
(C)	$4499.75Hz.$	$4500.25Hz.$
(D)	$4500Hz.$	$4500.5Hz.$

4. A wave traveling on a stretched Slinky® takes $2sec$ to make a round trip (back & forth) along the $5m$ Slinky®. It is noted that there are four antinodes and five nodes along the path. What is the frequency of this wave?

(A) ${}^{1}\!/_{2}\,Hz$ (B) $2Hz$ (C) $4Hz$ (D) $5Hz$

5. A standing wave is observed on a 120-cm rope held in place at both ends. The rope wave contains 3 antinodes when the frequency is 120-Hz. What is the fundamental frequency of this rope?

(A) $20Hz$ (B) $40Hz$ (C) $80Hz$ (D) $120Hz$

6. For a physics class project you construct a handmade musical instrument consisting of a tube closed at one end. What length tube should you construct in order to have it produce a fundamental frequency of $128Hz$; 'C' below middle 'C'?

(A) $66.4cm$ (B) $99.2cm$ (C) $1.33m$ (D) $1.51m$

7. You then build a tube open at *both* ends that produces the same fundamental frequency as the tube referred to in #6 above; $128Hz$; 'C' below middle 'C'. What is the length of this tube open at *both* ends?

(A) $66.4cm$ (B) $99.2cm$ (C) $1.33m$ (D) $1.51m$

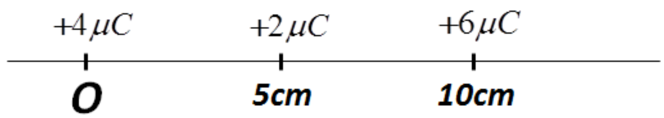
8. How many electrons must be removed from a neutral object so that it will acquire a net charge of $+1\mu C$?

(A) $6.25x10^{9}$ (B) $6.25x10^{12}$ (C) $1.60x10^{12}$ (D) $1.60x10^{19}$

9. What is the electrostatic force between two alpha particles (Helium nuclei, ${}^{2}_{4}He$) separated by a distance of $0.1nm$?

(A) $2.31x10^{-18}N$ (B) $9.22x10^{-18}N$ (C) $2.31x10^{-8}N$ (D) $9.22x10^{-8}N$

10. Two point charges are placed on an x-axis and held in place as shown below. A $+4\mu C$ charge is placed at the origin, ***O***, and a $+6\mu C$ charge is placed $10cm$ to the right of the origin. A third point charge of $+2\mu C$ is placed at the $5cm$ mark directly between the two original charges. What is the magnitude and direction of the net force acting on the $+2\mu C$ charge caused by the other two charges?



(A) $14.4N$ to the *left* (B) $14.4N$ to the *right* (C) $72N$ to the *left* (D) $72N$ to the *right*

11. By what factor must you change the distance between two point charges to increase the electrostatic force between them by a factor of 10?

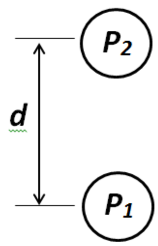
(A) Increase the distance by a factor of 10. (B) Decrease the distance by a factor of 10.

(C) Increase the distance by a factor of $\sqrt{10}$. (D) Decrease the distance by a factor of $\sqrt{10}$.

12. Two individual isolated protons near the surface of Earth are used in an experiment. Proton P_1 is held in place while another proton P_2 is dropped from some undisclosed distance much larger than ***d*** vertically above P_1. It is noticed that when P_2 reached a distance ***d*** directly above P_1, it stops falling and remains stationary. What is the distance ***d***?

(A) $0.014m$ (B) $0.028m$

(C) $0.117m$ (D) $0.234m$



13. You shuffle across your carpeted living room to open the front door when you are rudely shocked as you make contact with the doorknob. If a total charge of $0.5\mu C$ moves from your fingers to the doorknob in $0.1\mu\sec$, what is the electrical current?

(A) $5x10^{-6}A$ (B) $5x10^{-3}A$ (C) $0.5A$ (D) $5A$

14. A recurring theme on TV's *The Big Bang Theory* show is that one of the characters, Penny, continually ignores her "Check Engine" light. Assuming she drives a typical car with a $12V$ battery and the "Check Engine" light receives $25mA$ of current when lit, what is the resistance of Penny's "Check Engine" light?

(A) 0.3Ω (B) 0.48Ω (C) 300Ω (D) 480Ω

15. Most consumer batteries are "all the same." However, alkaline batteries have the advantage of being able to put out a constant voltage till just before the actual end of its useful life. If an alkaline battery is rated at $2.0A \cdot hr$ and $1.52V$, approximately how long can it keep a $0.25W$ flashlight bulb lit?

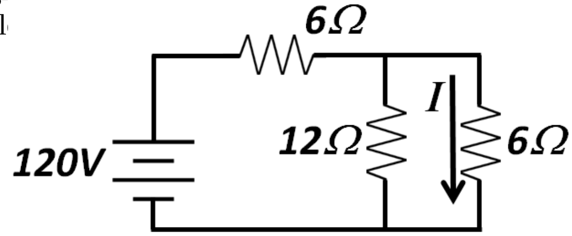
(A) $12hr$ (B) $6hr$ (C) $3hr$ (D) $1.5hr$

16. According to the US *EIA* (United States Energy Information Administration; www.eia.gov) there are 120 Million households in the US with television sets. The average household has 2.3 TVs each running for an average of 8.5 hours per day. That yields a whopping 276 Million TVs in the US. This does NOT include computers, tablets, or smartphones. The average TV runs on $120V$ at $150W$ and the average US electric charge from power companies is $\$0.12/kW \cdot hr$. Approximately what is the yearly monetary cost of running all these TVs for the aforementioned 8 hours per day?

(A) $\$14.5\,Million/year$ (B) $\$14.5\,Billion/year$ (C) $\$6.3\,Million/year$ (D) $\$6.3\,Billion/year$

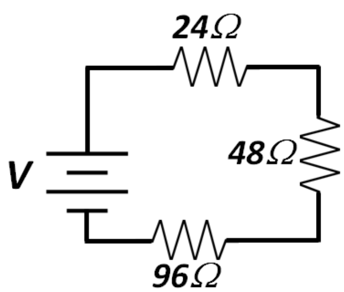
17. Which choice below represents the smallest equivalent resistance, R_{Eq}, possibly attained by connecting one 36Ω, one 500Ω, and one 1000Ω resistor together?
(A) 0.03Ω (B) 23.5Ω (C) 32.5Ω (D) 36Ω

18. In the circuit shown below, what is the magnitude and direction of the current through the 6Ω resistor oriented vertically on the right side of the circuit as label
(A) 8-*A* downward toward the bottom of page.
(B) 8-*A* upward toward the top of page.
(C) 4-*A* downward toward the bottom of page.
(D) 4-*A* upward toward the top of page.

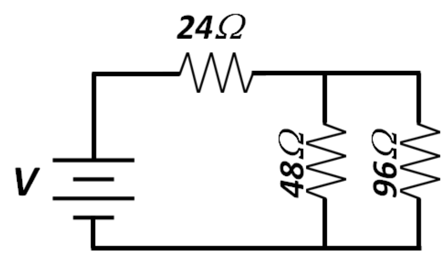


19. You are provided with three resistors and one battery or unknown non-zero *emf*. The three resistors have values of 24Ω, 48Ω, and 96Ω. You can connect the resistors in any configuration to the given battery. Which configuration below will cause the battery to deliver the greatest power to the circuit?

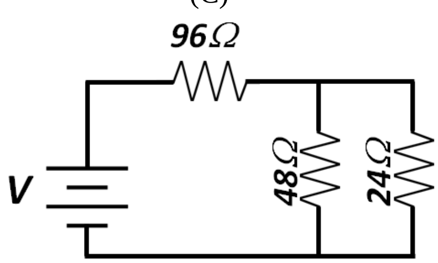
(A)



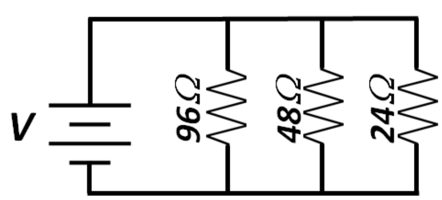
(B)



(C)

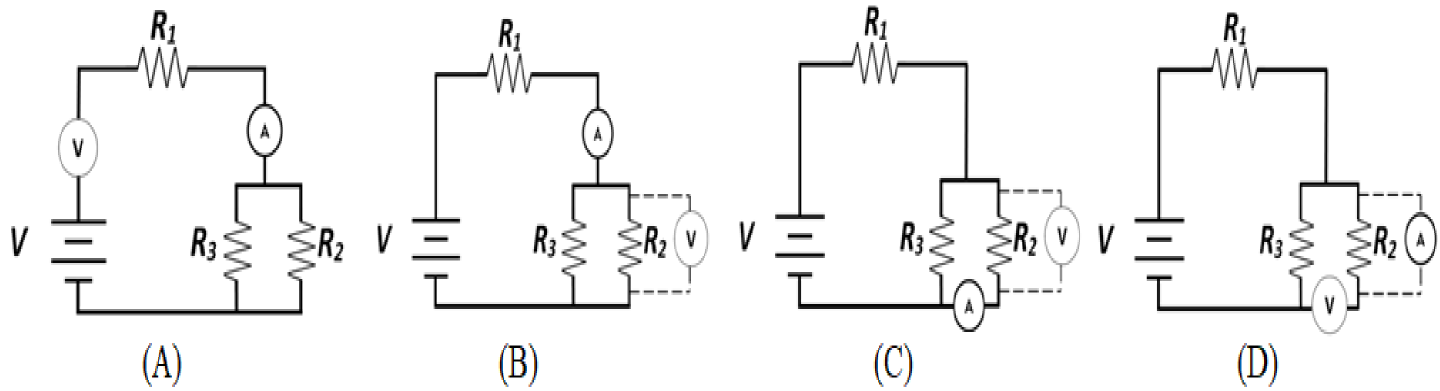


(D)

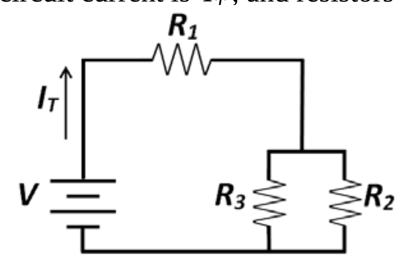


20. What is the internal resistance of a battery with an $emf = 3V$ that can deliver a current of $0.5A$ to a 4Ω resistor connected in series with the battery?
(A) 0.5Ω (B) 1Ω (C) 2Ω (D) 4Ω

21. Which of the following diagrams represents the proper method of using an Ammeter and a Voltmeter to measure the current through and potential difference across resistor R_2 ?



Use the following information for Questions #22 & #23: Use the basic circuit configuration from #21 above; shown below without the meters. The battery has terminal voltage V , total circuit current is I_T , and resistors R_1, R_2 , and R_3 are of unknown values.



22. In terms of the given variables, what is the potential difference across resistor R_2 ?

(A) $V - I_T R_1$ (B) $V - I_T R_3$

(C) $V - I_T \left(R_1 + R_3\right)$ (D) $V - I_T \left(R_1 - R_3\right)$

23. In terms of the given variables, what is the total current of the circuit, I_T ?

(A) $\dfrac{V}{R_1 + \dfrac{1}{\left(\dfrac{1}{R_2} + \dfrac{1}{R_3}\right)}}$ (B) $\dfrac{V}{R_1 - \dfrac{1}{\left(\dfrac{1}{R_2} + \dfrac{1}{R_3}\right)}}$ (C) $\dfrac{V}{R_1 + R_2 + R_3}$ (D) $\dfrac{V}{R_2 + R_3 + \dfrac{1}{R_3}}$

24. The threshold intensity of human hearing is defined to be $1x10^{-12}\, W/m^2$ which equates to $0dB$ (deci-Bell). Prolonged exposure to high sound levels can seriously damage the human ear. Any sound with intensity level of $90dB$ or higher is considered to be harmful. $90dB$ for 8 hours can cause permanent hearing damage as can 2 hours at $100dB$ and only 7 minutes at $120dB$, considered the “threshold for pain.” Personal ear-buds commonly worn today routinely crank out more than $100dB$ for extended periods of time. In W/m^2 , how much louder is a $120dB$ than a $80dB$ sound?

(A) 50% louder (B) $40\, W/m^2$ louder (C) 40 times louder (D) 10,000 times louder

25. Assume the orbit of Earth about the Sun to be circular. Use orbital radius R , Earth mass m , Sun mass M , and Universal Gravitation Constant G . Which of the following represents the total mechanical energy of the Earth as it orbits the Sun? Consider linear quantities only.

(A) $\dfrac{GMm}{2R}$ (B) $-\dfrac{GMm}{2R}$ (C) $\dfrac{GMm}{R^2}$ (D) $-\dfrac{GMm}{R^2}$

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

January Exam: Kinematic, Dynamics, Circular Motion, Universal Gravitation.
February Exam: impulse and linear momentum and conservation of linear momentum: collisions, Work and Energy, Conservation of Energy, Collisions, Plus review of Jan topics
March Exam: Rotational kinematics, torque, rotational dynamics Conservation of angular momentum, Simple Harmonic motion: simple pendulum, Mass-spring systems Plus review of Jan and Feb topics
April Exam: Introductory electrostatics: Concepts of electric charge Conservation of electric charge, Coulomb's Law, DC circuits (resistors only) Mechanical waves and sound, Plus review of Jan, Feb, and March topics.

Dates for 2018 Season

Thursday April 12, 2018

All return envelopes must be post marked by April 30th or scanned then emailed

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 for 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

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

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

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

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
$c_{water} = 4186 \frac{J}{kg^\circ K}$
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
ρ = momentum
λ = wavelength
ϕ = work function