UNIVERSITY OF SASKATCHEWAN

Department of Physics and Engineering Physics

Physics 115.3

FINAL EXAMINATION

December 16, 2017 Time: 180 minutes

NAME: SOLUTIONS STUDENT NO.: ____________

(Last) **Please Print** (Given)

LECTURE SECTION (please check):

❑ 01 Dr. D. Janzen
❑ 02 Dr. R. Pywell
❑ 03 B. Zulkoskey
❑ 97 Dr. A. Farahani
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INSTRUCTIONS:

1. This is a closed book exam.
2. The test package includes a test paper (this document), an exam booklet, a formula sheet, a scratch card and an OMR sheet. The test paper consists of 11 pages, including this cover page. **It is the responsibility of the student to check that the test paper is complete**.
3. Only a basic scientific calculator (e.g. Texas Instruments TI-30X series, Hewlett-Packard HP 10s or 30S) may be used. Graphing or programmable calculators, or calculators with communication capability, are **not** allowed.
4. Enter your name and student number on the cover of the test paper and check the appropriate box for your lecture section. Also enter your name on the exam booklet and scratch card.
5. Enter your name and encode your NSID on the OMR sheet, **using a pencil**.
6. The test paper, the exam booklet, the formula sheet, the scratch card, and the OMR sheet must all be submitted.
7. No test materials will be returned.

QUESTION #	MAX. MARKS	MARKS
A1-20	20	
B21-24	8	
B25-28	8	
B29-32	8	
B33-36	8	
B37-40	8	
B41-44	8	
MARK	out of 60:	

PART A

FOR EACH OF THE FOLLOWING QUESTIONS IN PART A, ENTER THE MOST APPROPRIATE RESPONSE ON THE OMR SHEET, USING A PENCIL. USE THE EXAM BOOKLET FOR YOUR ROUGH WORK.

A1. Which one of the following relationships is dimensionally consistent with an expression yielding a value for acceleration? In these equations, x is a distance, t is time, and υ is velocity.

(D)

(A) $\frac{\upsilon}{t^2}$ $\frac{L/T}{T^2}$ " L/T^3 (B) $\frac{\upsilon}{x^2}$ $\frac{L/T}{L^2}$ " $\frac{1}{LT}$ (C) $\frac{\upsilon^2}{t}$ $\frac{L^2/T^2}{T}$ " L^2/T^3 (D) $\frac{\upsilon^2}{x}$ $\frac{L^2/T^2}{L}$ " L/T^2 (E) $\frac{\upsilon^2}{x^2} = \frac{L^2/T^2}{L^2} = \frac{1}{T^2}$

A2. A car starts from rest, undergoes constant acceleration, and reaches a speed υ after a time interval Δt_1. The car then moves with constant velocity for a time interval Δt_2. $\Delta t_1 = \Delta t_2$ $= \Delta t$. Which one of the following statements is correct for the average velocity of the car over the time period $\Delta t_1 + \Delta t_2$?

(E)

$\Delta x_1 = \frac{1}{2}(0+\upsilon)\Delta t_1 = \frac{1}{2}\upsilon\Delta t$; $\Delta x_2 = \upsilon\Delta t_2 = \upsilon\Delta t$; $\bar{\upsilon} = \frac{\Delta x_1 + \Delta x_2}{\Delta t_1 + \Delta t_2}$

(A) $\frac{1}{4}\upsilon$ (B) $\frac{1}{3}\upsilon$ (C) $\frac{1}{2}\upsilon$ (D) $\frac{2}{3}\upsilon$ (E) $\frac{3}{4}\upsilon$

$\bar{\upsilon} = \frac{\frac{1}{2}\upsilon\Delta t + \upsilon\Delta t}{2\Delta t}$ $\boxed{\bar{\upsilon} = \frac{3}{4}\upsilon}$

A3. As a result of the coordinate system chosen to describe its motion, a car in straight line motion has a negative velocity and a positive acceleration. Which one of the following statements could possibly be correct for the motion of the car?

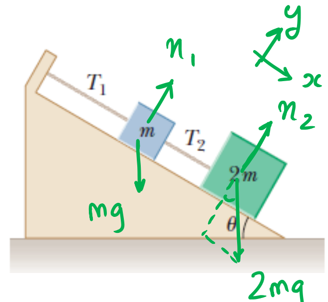
(D)

moving in negative direction; acceleration opposite to velocity ⇒ decreasing speed.

(A) The car is moving in the negative direction with increasing speed.
(B) The car is moving in the positive direction with increasing speed.
(C) The car is moving in the positive direction with decreasing speed.
(D) The car is moving in the negative direction with decreasing speed.
(E) The car is moving in the negative direction with constant speed.

A4. Two blocks of masses m and $2m$ are held in equilibrium on a frictionless incline as shown in the figure. What is the tension T_2 in the lower cord connecting the two blocks?

(B)



(A) $3\,mg\sin\theta$ (B) $2\,mg\sin\theta$ (C) $mg\sin\theta$
(D) $3\,mg$ (E) $2\,mg$

For mass 2m, $\Sigma F_x = 0 \Rightarrow 2mg\sin\theta - T = 0$

A5. When a bullet is fired from a rifle, the expanding gas released by exploding gunpowder accelerates the bullet down the barrel. Suppose that a constant force is exerted on the bullet by the gas as the gas expands and the bullet moves down the barrel. The speed of the bullet when it reaches the end of the barrel is V when the barrel has a certain length. If the length of the barrel is doubled, what would be the speed of the bullet leaving the end of the barrel?

(B)

(A) V (B) $\sqrt{2}\,V$ (C) $2V$ (D) $4V$ (E) $2\sqrt{2}\,V$

Constant force ⇒ constant acceleration ⇒ $\upsilon^2 = \upsilon_0^2 + 2a\Delta x$

L = original length of barrel ⇒ $V^2 = 2aL$; $L' = 2L \Rightarrow V'^2 = 2a(2L) = 2(2aL)$

$V'^2 = 2V^2$

$\therefore \boxed{V' = \sqrt{2}\cdot V}$

P_1 t_1

A6. (C) A 20-kW motor can raise an elevator, at a constant speed, 10 floors in 20 s. If we ignore friction, how long will it take a 40-kW motor to raise the same elevator the same 10 floors at a constant speed? P_2

Same # of floors, constant speed ⇒ same amount of work is being done.

(A) 40 s (B) 20 s (C) 10 s (D) 5 s
(E) We do not have enough information to answer the question.

$W = Pt \Rightarrow P_1 t_1 = P_2 t_2$

$t_2 = \frac{P_1 t_1}{P_2}$ $\boxed{= 10 s}$

A7. (C) A car, with mass m and initial kinetic energy K, collides with a stationary car with mass $2m$. After the collision the two cars are stuck together and move as one. What is the total kinetic energy of the two cars after the collision?

$p_f = p_i \Rightarrow (m+2m)v_f = mv \rightarrow 3mv_f = mv$

$v_f = \frac{1}{3}v$

(A) $\frac{1}{9}K$ (B) K (C) $\frac{1}{3}K$ (D) $\frac{1}{2}K$ (E) $\frac{2}{3}K$

$K_f = \frac{1}{2}(3m)v_f^2 = \frac{1}{2}(3m)(\frac{1}{3}v)^2 = \frac{1}{2}(3m)(\frac{1}{9}v^2) = \frac{1}{3}(\frac{1}{2}mv^2) = \frac{1}{3}K$

A8. (C) Two dimes are placed on a vinyl record that starts to rotate from rest. Dime one is 12 cm from the axis of rotation and dime two is 6.0 cm from the axis of rotation. Which one of the following statements best describes the angular acceleration of the dimes? rigid object, angular acceleration is the same at all points

(A) The angular acceleration of dime one is two times the angular acceleration of dime two.
(B) The angular acceleration of dime two is two times the angular acceleration of dime one.
(C) The angular acceleration of dime one is the same as the angular acceleration of dime two.
(D) The angular acceleration of dime one is four times the angular acceleration of dime two.
(E) The angular acceleration of dime two is four times the angular acceleration of dime one.

A9. (B) A car's speedometer senses the angular speed of the car's wheels and is calibrated to display the correct linear speed of the car when the factory-specified wheels and tires are used. What will be the effect of installing aftermarket wheels and tires that are 4% larger in diameter than the factory specifications? d = factory diameter, $d' = 1.04d$ = aftermarket diameter

Let ω = angular speed of wheels

(A) The speedometer will indicate a speed that is 4% higher than the actual speed of the car.
(B) The speedometer will indicate a speed that is 4% lower than the actual speed of the car.
(C) The speedometer will indicate a speed that is 6.28% higher than the actual speed of the car.
(D) The speedometer will indicate a speed that is 2% higher than the actual speed of the car.
(E) The speedometer will indicate a speed that is 2% lower than the actual speed of the car.

actual speed of car $= \omega(d'/2) = 1.04(\omega d/2)$; speedometer reading $= \omega d/2 \simeq 4\%$ lower than actual speed.

A10. (A) An object is moving in a horizontal circular path at a constant speed with a period T. If the period is shortened to $\frac{1}{2}T$ without changing the radius of the circle, what is the new centripetal acceleration in terms of the original centripetal acceleration, a_c?

$a_c = \frac{v^2}{r} = \frac{(2\pi r/T)^2}{r} = \frac{4\pi^2 r}{T^2}$

(A) $4a_c$ (B) $2a_c$ (C) a_c (D) $\frac{a_c}{2}$ (E) $\frac{a_c}{4}$

$a_c' = \frac{4\pi^2 r}{(\frac{1}{2}T)^2} = \frac{1}{(1/2)^2} \cdot \frac{4\pi^2 r}{T^2} = 4 \cdot \frac{4\pi^2 r}{T^2} = \boxed{4a_c}$

A11. (D) Two forces are acting on an object. Which one of the following statements is correct?

(A) The object is in equilibrium if the forces are equal in magnitude and opposite in direction.
(B) The object is in equilibrium if the net torque on the object is zero.
(C) The object is in equilibrium if the forces act at the same point on the object.
(D) The object is in equilibrium if the net force and the net torque on the object are both zero.
(E) The object cannot be in equilibrium because more than one force acts on it.

A12. A hoop is rolling without slipping across a horizontal surface with a speed V. A block is sliding across a frictionless horizontal surface with the same speed V. Both the hoop and the block have the same mass, M. What is the relationship between the total kinetic energy of the hoop, KE_{hoop}, and the total kinetic energy of the block, KE_{block}?

(B)

(A) $KE_{hoop} = 4KE_{block}$ (B) $KE_{hoop} = 2KE_{block}$ (C) $KE_{hoop} = KE_{block}$

(D) $KE_{hoop} = \frac{1}{2}KE_{block}$ (E) $KE_{hoop} = \frac{1}{4}KE_{block}$

$KE_{block} = \frac{1}{2}MV^2$

$KE_{hoop} = \frac{1}{2}MV^2 + \frac{1}{2}I\omega^2 = \frac{1}{2}MV^2 + \frac{1}{2}(MR^2)\left(\frac{V}{R}\right)^2 = MV^2 = \boxed{2KE_{block}}$

A13. A stone is tied to the end of a string and swung in a horizontal circle at constant angular speed. What can we say about the angular momentum of the string and stone system and the linear momentum of the stone?

(B)

direction of motion is changing, so $\vec{p}$ not constant

(A) The angular momentum is constant, and the linear momentum is constant.
(B) The angular momentum is constant, but the linear momentum is constantly changing.
(C) The linear momentum is constant, but the angular momentum is constantly changing.
(D) Both the linear momentum and the angular momentum are constantly changing.
(E) We cannot make any of the above conclusions without more information.

$L = I\omega = \text{constant}$

A14. An electron is accelerated from rest through a potential difference of 20 V. After passing through the potential difference, the kinetic energy of the electron is…

(A)

(A) 20 eV. (B) 20 J. (C) 3.2×10^{-18} eV. (D) 1.6×10^{-19} eV. (E) 10 J.

$|\Delta KE| = |\Delta PE| = |q\Delta V| = |(-e)(20V)| = \boxed{20eV}$

A15. A uniform electric field exists in a region of space. It has a magnitude of 40 N/C and is directed toward the south. At a point, P, in this region of space the electric potential is measured to be 80 V relative to ground. What is the electric potential relative to ground at a place that is 1.0 m North of the point P?

(A)

$\Delta V = -E\Delta x$

$\vec{E}$ • S • P (80V) 1.0m

(A) 120 V (B) 100 V (C) 60 V (D) 40 V
(E) It is impossible to calculate the answer from the given information.

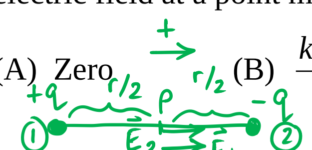
$\vec{E}$ points in the direction of decreasing potential. ∴ S is $E\Delta x$ higher in potential than P.

$V_S = 80V + \left(40\frac{N}{C} \cdot 1.0m\right) = 120V$

A16. Two small spheres have the same magnitude of charge, q. One is positive, and the other is negative. The centres of the spheres are separated by a distance r. What is the magnitude of the electric field at a point midway between the charges?

(E)

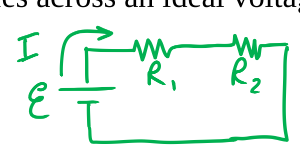
(A) Zero (B) $\frac{k_e q}{r}$ (C) $\frac{2k_e q}{r^2}$ (D) $\frac{4k_e q}{r^2}$ (E) $\frac{8k_e q}{r^2}$



$E = E_1 + E_2 = \frac{k_e|q|}{(r/2)^2} + \frac{k_e|-q|}{(r/2)^2} = 4\frac{k_e q}{r^2} + 4\frac{k_e q}{r^2} = \boxed{8\frac{k_e q}{r^2}}$

A17. Consider two resistors of unequal resistance connected in series across an ideal voltage source. Which one of the following statements is correct?

(B)



(A) The voltage drop across each resistor is the same.
(B) The current through each resistor is the same.
(C) The power dissipated in each resistor is the same.
(D) The equivalent resistance of the series combination equals the average of the individual resistances.
(E) The equivalent resistance of the series combination is less than the larger of the two resistances.

A18. The terminals of a battery are connected across the parallel combination of two resistors of unequal resistance. Which one of the following statements is correct?

(B)

Voltage drop is the same for parallel resistors.

$I_1 R_1 = I_2 R_2$

$I_2 = I_1 \left(\frac{R_1}{R_2}\right)$

- (A) The current through the larger resistance is greater than the current through the smaller resistance.
- (B) The current through the larger resistance is less than the current through the smaller resistance.
- (C) The current through each resistor is the same.
- (D) The voltage drop across the smaller resistance is greater than the voltage drop across the larger resistance.
- (E) The voltage drop across the smaller resistance is less than the voltage drop across the larger resistance.

A19. A charged particle is traveling through a region where there is a uniform magnetic field. Which one of the following statements is correct regarding the effect of the magnetic field on the charged particle?

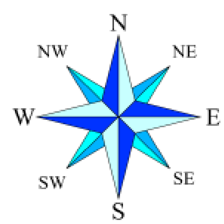
(D)

$\vec{F} = q\vec{v} \times \vec{B}$ (RHR)

- (A) The magnetic field exerts a force on the particle that is parallel to the field.
- (B) The magnetic field exerts a force on the particle that is along the particle's direction of motion.
- (C) The magnetic field increases the kinetic energy of the particle.
- (D) The magnetic field exerts a force that is perpendicular to the direction of motion of the particle.
- (E) The magnetic field does not change the velocity of the particle.

A20. You are holding a negatively-charged ball while standing at the Earth's magnetic equator, where the magnetic field direction is horizontal and points to North. You now drop the ball. The initial direction of the magnetic force acting on the ball is… (image: http://cliparts.co/clipart/3775881)

(B)



(A) East. (B) West. (C) South. (D) North.
(E) undefined. There is no magnetic force acting on the ball as it falls.

$\vec{F} = q\vec{v} \times \vec{B}$; RHR

PART B

WORK OUT THE ANSWERS TO THE FOLLOWING PART B QUESTIONS.

YOU MAY ANSWER ALL SIX PART B QUESTION GROUPINGS (21-24, 25-28, 29-32, 33-36, 37-40, AND 41-44) AND YOU WILL RECEIVE THE MARKS FOR YOUR BEST 5 GROUPINGS.

USE THE PROVIDED EXAM BOOKLET FOR YOUR ROUGH WORK.

WHEN YOU HAVE AN ANSWER THAT IS ONE OF THE OPTIONS AND ARE CONFIDENT THAT YOUR METHOD IS CORRECT, SCRATCH THAT OPTION ON THE SCRATCH CARD. IF YOU REVEAL A STAR ON THE SCRATCH CARD THEN YOUR ANSWER IS CORRECT (FULL MARKS, 2/2).

IF YOU DO NOT REVEAL A STAR WITH YOUR FIRST SCRATCH, TRY TO FIND THE ERROR IN YOUR SOLUTION. IF YOU REVEAL A STAR WITH YOUR SECOND SCRATCH, YOU RECEIVE HALF-MARKS (1/2).

IF YOU STILL DO NOT HAVE THE CORRECT ANSWER, BUT REWORK YOUR SOLUTION AND REVEAL A STAR WITH YOUR THIRD SCRATCH, THEN YOU RECEIVE 0.2/2.

REVEALING THE STAR WITH YOUR FOURTH OR FIFTH SCRATCHES DOES NOT EARN YOU ANY MARKS, <u>BUT IT DOES GIVE YOU THE CORRECT ANSWER</u>.

Grouping B21 to B24:

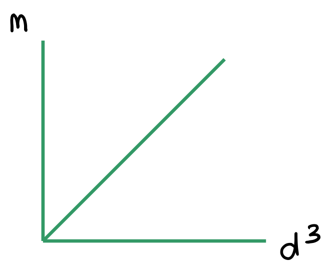
The density of an object is defined as the mass of the object divided by its volume. If the object is solid and made of the same material throughout, then the density of the object is the same as the density of the material, ρ, of which it is made.

B21. What are the SI units of density?

$$\rho = \frac{M}{V} = \frac{kg}{m^3}$$

kg/m^3

B22. You measure the diameters and masses of a number of solid steel balls. Which one of the following graphs best represents the expected relationship between the masses, *m*, and diameters, *d*?



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

$$m = \rho\left(\frac{4}{3}\pi\left(\frac{d}{2}\right)^3\right)$$

$$m = \rho \cdot \frac{4}{3}\pi \frac{d^3}{8}$$

$$m = \frac{4}{24}\pi\rho d^3 = \frac{1}{6}\pi\rho d^3$$

$$\Downarrow$$

$$m \propto d^3$$

B23. As suggested in the previous question, the mass of a steel ball is expected to be proportional to some power of the diameter. Which one of the following values is the expected constant of proportionality?

$$\frac{1}{6}\pi\rho$$

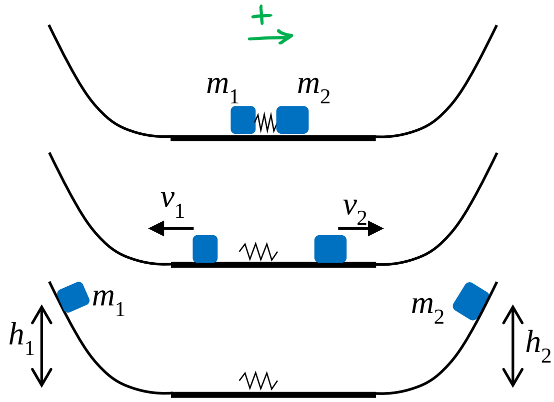
B24. A steel ball with a diameter of 16 mm has a mass of *m*. What is the diameter of a steel ball with a mass of $\frac{1}{8}m$?

$$m \propto d^3 \Rightarrow d \propto \sqrt[3]{m} \Rightarrow \frac{d_2}{d_1} = \sqrt[3]{\frac{m_2}{m_1}} = \sqrt[3]{\frac{(1/8)m}{m}} = \sqrt[3]{\frac{1}{8}} = \frac{1}{2}$$

$$d_2 = \frac{1}{2}d_1 = \frac{1}{2}(16\text{ mm}) = 8.0\text{ mm}$$

Grouping B25 to B28:

Two blocks of ice, with masses m_1 and m_2, are on the bottom of a bowl. We can ignore friction between the ice blocks and the bowl. A light spring is placed between the ice blocks and they are pushed together as shown in the top diagram at right. The blocks are then released. The spring drops between them (we can ignore the mass of the spring) and the blocks are moving away at speeds v_1 and v_2. This is the situation depicted in the middle diagram. The blocks then slide up the sides of the bowl. Block m_1 reaches a maximum height h_1 above its initial position, and m_2 reaches a maximum height h_2 as shown in the bottom diagram.



B25. Which one of the following is the correct relationship between the speeds v_1 and v_2?

$$v_2 = \frac{m_1}{m_2} v_1$$

$\vec{p}_f = \vec{p}_i$

$-m_1 v_1 + m_2 v_2 = 0$

$m_2 v_2 = m_1 v_1$

$v_2 = \frac{m_1}{m_2} v_1$

B26. Which principle of physics must be used to determine the correct answer to B25?

Conservation of Linear Momentum

No friction $\Rightarrow$ Conservation of Mechanical Energy

$\therefore m_1 g h_1 = \frac{1}{2} m_1 v_1^2$ and $m_2 g h_2 = \frac{1}{2} m_2 v_2^2$

$h_1 = \frac{v_1^2}{2g}$; $h_2 = \frac{v_2^2}{2g} = \frac{\left(\frac{m_1}{m_2} \cdot v_1\right)^2}{2g}$

B27. What is the correct relationship between the heights h_1 and h_2?

$$h_2 = \left(\frac{m_1}{m_2}\right)^2 h_1$$

$h_2 = \frac{m_1^2}{m_2^2} \cdot \frac{v_1^2}{2g}$

$h_2 = \left(\frac{m_1}{m_2}\right)^2 \cdot h_1$

B28. The masses are $m_1 = 20.0$ g and $m_2 = 40.0$ g, and the height $h_1 = 3.00$ cm. If the spring was compressed a distance $x = 2.00$ cm before being released, calculate the spring constant of the spring.

Initially, all the energy is stored in the spring: $\frac{1}{2}kx^2 = m_1 g h_1 + m_2 g h_2$

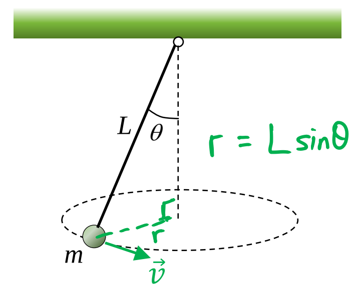
$\frac{1}{2}kx^2 = m_1 g h_1 + m_2 g \left(\frac{m_1}{m_2}\right)^2 h_1$

$\frac{1}{2}kx^2 = m_1 g h_1 + \frac{m_1^2 g h_1}{m_2} = m_1 g h_1 \left(1 + \frac{m_1}{m_2}\right)$

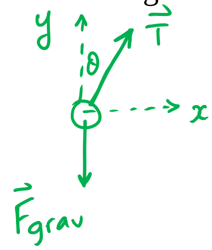
$k = \frac{2 m_1 g h_1}{x^2}\left(1 + \frac{m_1}{m_2}\right) = 44.1 \text{ N/m}$

Grouping B29 to B32:

A ball of mass m on the end of a massless string of length L is moving in a horizontal circle at constant speed v as shown in the diagram. The string makes an angle of θ with the vertical and the tension in the string has a magnitude of T.



$a_c = \frac{v^2}{r}$ = constant (non-zero)



constant speed $\Rightarrow \alpha = 0$ and $a_t = 0$

B29. Which one of the following statements is correct?

The ball has a non-zero centripetal acceleration, but its tangential and angular accelerations are zero.

B30. Which one of the following is the correct expression for the magnitude of the centripetal force acting on the ball?

ΣF_{radial} = horizontal component of tension = $\boxed{T\sin\theta}$

$\Sigma F_x = ma_c \Rightarrow T\sin\theta = \frac{mv^2}{r}$

The following values apply to questions B31 and B32: L = 40.0 cm, θ = 60.0°

$\Sigma F_y = 0 \Rightarrow_+ T\cos\theta - mg = 0$

$T = \frac{mg}{\cos\theta}$

B31. Calculate the speed of the ball.

$$\therefore \left(\frac{\cancel{m}g}{\cos\theta}\right)\sin\theta = \frac{\cancel{m}v^2}{L\sin\theta} \Rightarrow v = \sqrt{\frac{gL\sin^2\theta}{\cos\theta}} = \boxed{2.42\text{ m/s}}$$

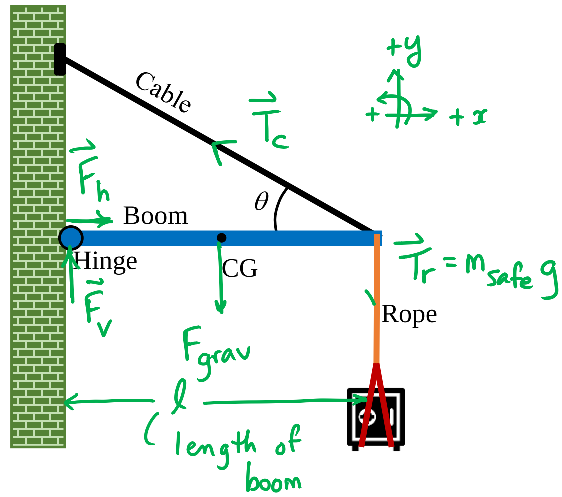
B32. Calculate the time for the ball to go around the circle exactly once.

$$v = \frac{2\pi r}{\text{Period}} \Rightarrow \text{Period} = \frac{2\pi r}{v} = \frac{2\pi L\sin\theta}{v} = \frac{2\pi(0.400\text{m})(\sin 60.0°)}{2.42\text{ m/s}} = \boxed{0.899\text{s}}$$

(using unrounded answer for B31, Period = 0.898s)

Grouping B33 to B36:

The diagram shows a safe, with mass 325 kg, suspended by a rope attached to the end of a boom. The boom is a uniform rod of length 1.75 m and mass 85.0 kg and its center of gravity (CG) is at the center of the boom. The other end of the boom is attached to the wall by a hinge, about which it is free to rotate. The boom is prevented from rotating by a cable between the wall and the end of the boom. The cable makes an angle $\theta = 35.0°$ with the boom. The masses of the cable and the rope are negligible.



$$\sum \tau_{hinge} = -m_{boom}\, g \frac{\ell}{2} + T_c\, \ell \sin\theta - T_r\, \ell = 0$$

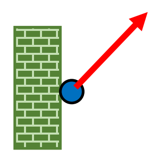
$$T_c = \left(\frac{m_{boom}\, g}{2} + m_{safe}\, g\right) \Big/ \sin\theta = 6.28 \times 10^3\ \text{N}$$

B33. If torques on the boom are calculated about an axis of rotation at the center of gravity of the boom, which of the following forces produces zero torque about that axis?

The weight of the boom

B34. Which direction, as shown in the diagram at right, best represents the direction of the force on the boom from the hinge?

force from hinge must have a horizontal component to the right because the tension in the cable has a horizontal component to the left.



B35. Calculate the magnitude of the tension in the cable.

If rotation axis is taken to be the far end of the boom, then torque equilibrium shows that the force of the hinge must have a vertical component (upward)

B36. The hanging safe is now removed, so that just the boom is supported by the cable. At some later time, the cable between the boom and the wall suddenly breaks. What is the magnitude of the tangential acceleration (a_t) of the free end of the boom at the instant just after the cable breaks?

$\sum \tau = I\alpha$; $a_t = \ell\alpha$

When the cable breaks, the only force exerting a torque about the hinge is the weight of the boom. $\therefore\ m_{boom}\, g \frac{\ell}{2} = \frac{1}{3} m_{boom}\, \ell^2 \cdot \alpha \Rightarrow \alpha = \frac{3g}{2\ell}$

$$\therefore a_t = \left(\frac{3g}{2\ell}\right)\ell = \frac{3}{2}g$$

Grouping B37 to B40:

$E = \frac{k_e|q|}{r^2}$

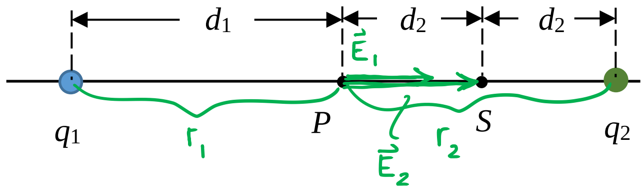
B37. Which one of the following statements correctly describes the electric field created by a positive point charge?

The electric field is directed away from the point charge, and its magnitude is proportional to the inverse of the square of the distance from the point charge.

$r_1 = r_2 = 0.0600\text{m}$

$E_1 = \frac{k_e|q_1|}{r_1^2} = 1.123 \times 10^7 \text{ N/C}$

The following diagram and information apply to questions B38, B39, and B40:



$E_2 = \frac{k_e|q_2|}{r_2^2} = 1.673 \times 10^7 \text{ N/C}$

The two point charges q_1 and q_2 are fixed in place, they cannot move.
q_1 = +4.50 μC, q_2 = –6.70 μC, d_1 = 6.00 cm, d_2 = 3.00 cm.

$E_P = E_1 + E_2$

B38. Calculate the net electric field at *P*.

$\boxed{E_P = 2.80 \times 10^7 \text{ N/C}}$

$$V_P = V_1 + V_2 = \frac{k_e q_1}{r_1} + \frac{k_e q_2}{r_2} = \left(8.99 \times 10^9 \frac{\text{N}\cdot\text{m}^2}{\text{C}^2}\right)\left[\frac{+4.50\times10^{-6}\text{C}}{0.0600\text{ m}} + \frac{(-6.70\times10^{-6}\text{C})}{0.0600\text{m}}\right] =$$

B39. Calculate the absolute electric potential at *P*, given that the potential is zero at a point infinitely far away.

$\boxed{-3.30 \times 10^5 \text{V}}$

Energy is conserved: $KE_P + PE_P = KE_S + PE_S \Rightarrow 0 + qV_P = \frac{1}{2}mv_S^2 + qV_S \Rightarrow v_S = \sqrt{\frac{2q}{m}(V_P - V_S)}$

B40. A small object of mass 1.50 × 10⁻⁶ g, with an electric charge of +2.80 μC, is released from rest at point *P*. Calculate the speed of the object when it reaches point *S*. You may ignore any gravitational effects.

$$V_S = \frac{k_e q_1}{0.0900\text{m}} + \frac{k_e q_2}{0.0300\text{m}} = \left(8.99\times10^9 \frac{\text{N}\cdot\text{m}^2}{\text{C}^2}\right)\left[\frac{4.50\times10^{-6}\text{C}}{0.0900\text{m}} + \frac{-6.70\times10^{-6}\text{C}}{0.0300\text{m}}\right]$$

$V_S = -1.558 \times 10^6 \text{ V}$

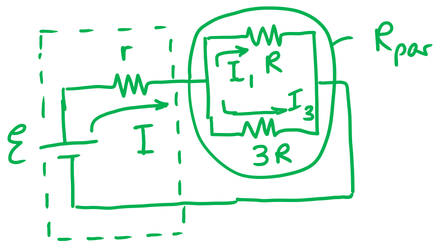
$$\therefore v_S = \left[\frac{2(2.80\times10^{-6}\text{C})}{1.50\times10^{-9}\text{kg}}\left(-3.30\times10^5\text{V} - (-1.558\times10^6\text{V})\right)\right]^{1/2} = \boxed{6.77\times10^4 \text{ m/s}}$$

Grouping B41 to B44:

B41. A resistor of resistance R and a resistor of resistance $3R$ are connected in parallel. The equivalent resistance of this parallel combination is…

$$R_{par} = \left(\frac{1}{R_1} + \frac{1}{R_2}\right)^{-1} = \left(\frac{1}{R} + \frac{1}{3R}\right)^{-1} = \left(\frac{3}{3R} + \frac{1}{3R}\right)^{-1} = \left(\frac{4}{3R}\right)^{-1} = \frac{3R}{4} = \frac{3}{4}R$$

B42. The parallel combination of resistors described in B41, with $R = 24.7\ \Omega$, is now connected to a real battery with an emf of 9.20 V and an internal resistance of 3.16 Ω. Calculate the current drawn from the battery.



$$\mathcal{E} = I(r + R_{par})$$

$$I = \frac{\mathcal{E}}{\left(r + \frac{3}{4}R\right)} = \frac{9.20\text{V}}{\left(3.16\Omega + \frac{3(24.7\Omega)}{4}\right)} = 0.424\text{A}$$

B43. Calculate the energy dissipated internally in the battery when the circuit has been on for a time of 1.50 minutes.

$$P_i = I^2 r = \frac{E_i}{t} \Rightarrow E_i = I^2 r t = (0.424\text{A})^2(3.16\Omega)(1.50\text{ min})\left(\frac{60\text{ s}}{\text{min}}\right)$$

$$E_i = 51.1\text{J}$$

$$IR_{par} = I_1 R = I_3(3R) \quad \text{(see circuit diagram)}$$

$$\therefore\ I_1 = \frac{IR_{par}}{R} = \frac{(0.424\text{A})(\frac{3}{4}R)}{R} = 0.318\text{A}$$

B44. Calculate the amount of charge that has flowed through the 24.7 Ω resistor in a time of 1.50 minutes.

$$Q_1 = I_1 t = (0.318\text{A})(1.50\text{ min})\left(\frac{60\text{ s}}{\text{min}}\right) = 28.6\text{C}$$

END OF EXAMINATION