UNIVERSITY OF SASKATCHEWAN

Department of Physics and Engineering Physics

Physics 115.3 ~~General~~ Physics and the Universe √*

FINAL EXAMINATION

December 6, 2010 Time: 3 hours

NAME: MASTER STUDENT NO.: ________________
(Last) **Please Print** (Given)

LECTURE SECTION (please check):

- ☐ 01 B. Zulkoskey
- ☐ 02 Dr. R. Pywell
- ☐ 03 Dr. K. McWilliams
- ☐ C15 F. Dean

INSTRUCTIONS:

1. You should have a test paper, a formula sheet, and an OMR sheet. The test paper consists of 11 pages. **It is the responsibility of the student to check that the test paper is complete.**
2. Enter your name and STUDENT NUMBER on the OMR sheet.
3. The test paper, the formula sheet and the OMR sheet must all be submitted.
4. None of the test materials will be returned.
5. This is a closed book examination.
6. Only Hewlett-Packard HP 10S or 30S or Texas Instruments TI-30X series calculators may be used.

ONLY THE FIVE PART B QUESTIONS THAT YOU INDICATE WILL BE MARKED

PLEASE INDICATE WHICH FIVE PART B QUESTIONS ARE TO BE MARKED

QUESTION NUMBER	TO BE MARKED	MAXIMUM MARKS	MARKS OBTAINED
A1-25	☑	25	
B1	☐	10	
B2	☐	10	
B3	☐	10	
B4	☐	10	
B5	☐	10	
B6	☐	10	
TOTAL		75	

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PART A

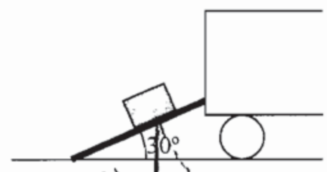
FOR EACH OF THE FOLLOWING QUESTIONS IN PART A, ENTER THE MOST APPROPRIATE RESPONSE ON THE OMR SHEET.

A1. Which one of the following expressions for the height of the Eiffel Tower is properly written in scientific notation with 4 significant figures?

(A) 324.0 m (B) 32.4×10^1 m (C) 0.3240×10^3 m

(D) 3.24×10^2 m (E) 3.240×10^2 m

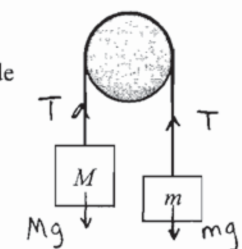
A2. A box of mass m rests on an inclined plank that makes an angle of 30° with the horizontal, as shown in the diagram. Which one of the following statements about the magnitude of the force of static friction on the box is **TRUE**?



(A) $f_s > mg$ (B) $f_s > mg\sin 30°$ (C) $f_s > mg\cos 30°$

(D) $f_s = mg\sin 30°$ (E) $f_s = mg\cos 30°$

A3. Two masses, M and m, with $M > m$, are attached to a string with negligible mass and passed over an ideal pulley (negligible mass and negligible friction). The mass M accelerates downwards. The magnitude of its acceleration is



(A) g (B) $\frac{M}{m}g$ (C) $\frac{m}{M}g$ (D) $\frac{M-m}{Mm}g$ (E) $\frac{M-m}{M+m}g$

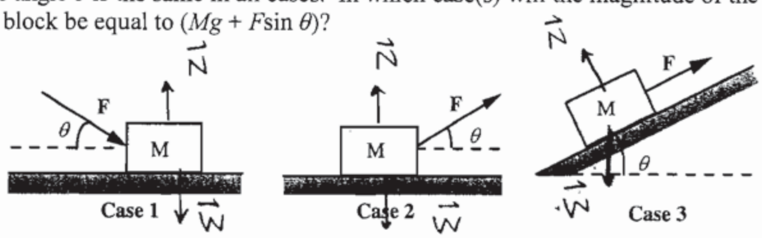
A4. Which one of the following is a vector quantity?

(A) mass (B) work (C) energy (D) impulse (E) time

A5. A ball is thrown straight up into the air. Ignoring air resistance, while in the air, the ball's acceleration…

(A) is zero.
(B) increases.
(C) decreases on the way up and increases on the way back down.
(D) remains constant.
(E) changes direction.

A6. Consider the following three situations in which a block of mass M experiences an applied force **F**. The angle θ is the same in all cases. In which case(s) will the magnitude of the normal force on the block be equal to ($Mg + F\sin\theta$)?



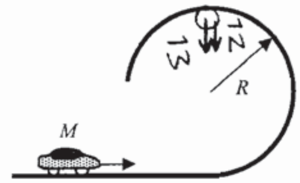
(A) case 1 only (B) case 2 only (C) both cases 1 and 2

(D) both cases 2 and 3 (E) cases 1, 2, and 3

continued on page 3...

D

A7. A small car of mass *M* travels along a straight, horizontal track, part of which is shown in the figure. The track bends into a vertical circle of radius *R*. When the car reaches the top of the track it is travelling with the minimum speed required to maintain contact with the track. What is the acceleration at the top of the track?

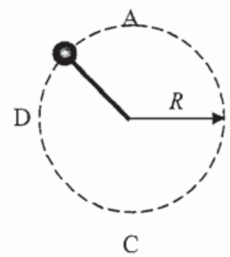


At top, $W + N = Ma$ $N = 0$ at min. speed
$W = Ma \Rightarrow a = g$

(A) ½ *g*, downward (B) ½ *g*, upward (C) *g*, upward
(D) *g*, downward (E) 2*g*, upward

A

A8. A ball of mass *m* on the end of a rope moves in a vertical circle of radius *R* near the surface of the Earth. Point **A** is at the top of the circle; **C** is at the bottom. How does the kinetic energy of the ball at **C** compare to its kinetic energy at **A**?



(A) $K_C = K_A + 2mgR$ (B) $K_C = K_A - 2mgR$
(C) $K_C = K_A + mgR$ (D) $K_C = K_A + ½mgR$
(E) $K_C = K_A \times 2mgR$

A

A9. A ball is thrown against a wall. It rebounds with no change in speed. Which one of the following statements is <u>**TRUE**</u>?

(A) The ball's kinetic energy is also unchanged.
(B) The ball's momentum is also unchanged.
(C) Both kinetic energy and momentum are unchanged.
(D) Both kinetic energy and momentum change.
(E) The question cannot be answered without knowing whether or not the ball hit the wall "head on".

C

A10. The magnitude of the electrostatic force between two charged particles is *F*. If the distance between the two particles is reduced by a factor of two and the charge on one of the particles is doubled then the magnitude of the electrostatic force… $F = k|q_1||q_2|/r^2$

(A) increases by a factor of 2. (B) increases by a factor of 4. (C) increases by a factor of 8.
(D) decreases by a factor of 4. (E) is unchanged. $F_2 = \frac{2k|q_1||q_2|}{(r/2)^2} = 8\frac{k|q_1||q_2|}{r^2} = 8F$

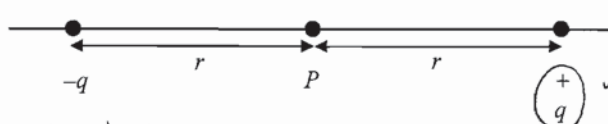
D

A11. Which one of the following statements is <u>**TRUE**</u> regarding a proton and an electron in identical electric fields?

(A) The magnitude of the electric force on the electron is larger than the magnitude of the electric force on the proton.
(B) The magnitude of the electric force on the proton is larger than the magnitude of the electric force on the electron.
(C) The direction of the electric force on the electron is the same as the direction of the electric force on the proton.
(D) The magnitude of the acceleration of the electron is larger than the magnitude of the acceleration of the proton.
(E) The magnitude of the acceleration of the proton is larger than the magnitude of the acceleration of the electron.

E

A12. A charge +*q* and a charge –*q* are held a distance of 2*r* apart on the *x*-axis.



Add question! make eq'ns larger

(A) zero (B) $k\frac{|q|}{4r^2}$ to the right (C) $k\frac{|q|}{4r^2}$ to the left
(D) $2k\frac{|q|}{r^2}$ to the right (E) $2k\frac{|q|}{r^2}$ to the left

What is the ~~The magnitude of the~~ electric field at point P midway between the charges? ~~is~~

continued on page 4...

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A13. Which one of the following statements best describes electric potential difference?

(A) electric force per unit distance
(B) electric force per unit charge
(C) electric field per unit distance
(D) change in electric potential energy per unit distance
(E) change in electric potential energy per unit charge

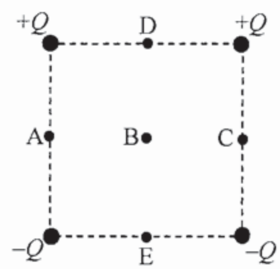
A14. Consider a capacitor connected to an ideal voltage source. Which one of the following statements correctly describes the effect when the capacitor plates are moved closer together?

(A) The amount of charge on either plate of the capacitor increases.
(B) The amount of charge on either plate of the capacitor decreases.
(C) The amount of charge on the capacitor does not change.
(D) The voltage drop across the capacitor increases.
(E) The voltage drop across the capacitor decreases.

A15. Consider two resistors of unequal resistance connected in parallel across an ideal voltage source. Which one of the following statements is **<u>TRUE</u>**?

(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 parallel combination equals the average of the individual resistances.
(E) The equivalent resistance of the parallel combination is greater than the larger of the two resistances.

A16. Consider the four charges, arranged at the corners of a square, as shown in the diagram. All charges have the same magnitude, Q, but the signs of the charges are as shown in the diagram. Point B is at the centre of the square and points A, C, D, and E are at the centres of the sides of the square. Defining electric potential to be zero at an infinite distance away, at which of the labelled points is the electric potential zero?



(A) Points A, B and C only.
(B) Points D, B and E only.
(C) Point B only.
(D) Points A, B, C, D and E.
(E) None of the points are at zero electric potential.

A17. Two metal rods have exactly the same resistance between their ends. Rod A has a length L_A and diameter D_A. The length L_B and diameter D_B of rod B are related to L_A and D_A by $L_B = 2L_A$ and $D_B = 2D_A$. It follows that the resistivity of rod B, ρ_B, is related to the resistivity of rod A, ρ_A, by

(A) $\rho_A = \frac{1}{4}\rho_B$ (B) $\rho_A = \frac{1}{2}\rho_B$ (C) $\rho_A = \rho_B$ (D) $\rho_A = 2\rho_B$ (E) $\rho_A = 4\rho_B$

A18. Consider a proton moving horizontally eastward that enters a region where there is a uniform magnetic field directed horizontally northward. The uniform magnetic field is much greater than the Earth's magnetic field. The direction of the magnetic force acting on the proton when it first enters the magnetic field is

(A) UP (B) DOWN (C) EAST (D) WEST (E) NORTH

A19. A charged particle is moving in a uniform, constant magnetic field. Which one of the following statements concerning the magnetic force exerted on the particle is **<u>FALSE</u>**?

(A) It does no work on the particle.
(B) It increases the speed of the particle.
(C) It changes the velocity of the particle.
(D) It can act only on a particle in motion.
(E) It does not change the kinetic energy of the particle.

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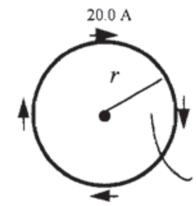
A20. A wire is bent into the shape of a circle of radius r and carries a 20.0-A current in the clockwise direction, as shown. What is the direction of the magnetic field at the centre of the loop?



(A) to the right of the page
(B) to the left of the page
(C) toward the top of the page
(D) into the plane of the page
(E) out of the plane of the page

A21. In the photoelectric effect, light falling on a metal surface causes electrons to be ejected from the surface. Which one of the following statements is <u>**TRUE**</u>?

(A) The maximum energy of the ejected electrons is independent of the type of metal. F
(B) The maximum energy of the ejected electrons is independent of the wavelength of the incident light. F
(C) Electrons are only ejected if the wavelength of the incident light is greater than some minimum threshold value. F
(D) The maximum energy of the ejected electrons is independent of the intensity of the incident light. T
(E) The number of electrons ejected per second increases linearly with frequency of the incident light. F

A22. A beam of X-rays, all with frequency f, are incident on a substance that scatters the beam in various directions away from the incident direction. We measure the frequencies of these scattered X-rays. We find that

(A) some of the scattered X-rays have frequencies less than f.
(B) some of the scattered X-rays have frequencies greater than f.
(C) all the scattered X-rays have frequencies equal to f.
(D) the scattered X-rays have frequencies that range from less than f to greater than f.
(E) None of the above, the answer depends on the type of substance that scatters the X-rays.

A23. Which one of the following statements is <u>**TRUE**</u>?

(A) In a vacuum, ultraviolet photons travel faster than infrared photons. F
(B) Photons have either a positive or negative charge. F
(C) An ultraviolet photon contains more energy than an infrared photon. T
(D) Photons do not have momentum since they have zero rest mass. F
(E) An ultraviolet photon has a longer wavelength than an infrared photon. F

A24. An X-ray machine produces photons with energy ~~49,600 eV~~ of E or less. Which one of the following ~~phrases~~ most accurately describes the wavelength of these photons?

(A) ~~0.025 nm~~ hc/E or longer
(B) ~~0.050 nm~~ E/hc or longer
(C) ~~0.75 nm~~ hc/E or ~~longer~~ shorter
(D) ~~0.25~~ nm E/hc or shorter
(E) ~~0.75 nm~~ Ec/h or shorter

$\frac{hc}{\lambda_{min}} = eV \Rightarrow \lambda_{min} = \frac{hc}{eV}$

A25. When we say that the electron energy levels in an atom are quantized, we mean that

(A) electric charge exists only in multiples of a small quantity (which we call 'e').
(B) the rest mass of the electron has a number of different, discrete values.
(C) the energy of an electron in an atom has a number of certain, discrete values, not a continuum of values as we would have expected. (can have)
(D) the total energy of all the electrons in an atom always adds up to a definite 'quantifiable' value.
(E) the energy of the electrons in an atom can only have one value.

fix formatting ✓

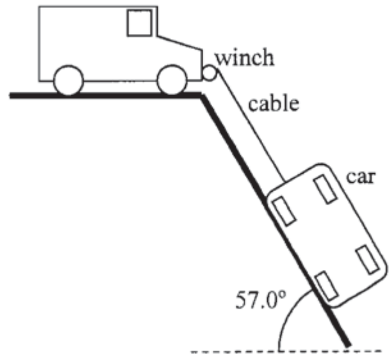
PART B

ANSWER FIVE PART B QUESTIONS AND INDICATE YOUR CHOICES ON THE COVER PAGE.

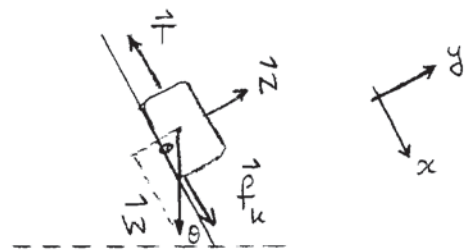
IN EACH OF THE PART B QUESTIONS ON THE FOLLOWING PAGES, GIVE THE COMPLETE SOLUTION AND ENTER THE FINAL ANSWER IN THE BOX PROVIDED. THE ANSWERS MUST CONTAIN THREE SIGNIFICANT FIGURES AND THE UNITS MUST BE GIVEN. <u>SHOW AND EXPLAIN YOUR WORK</u> – NO CREDIT WILL BE GIVEN FOR ANSWERS ONLY. EQUATIONS NOT PROVIDED ON THE FORMULAE SHEET MUST BE DERIVED. USE THE BACK OF THE PREVIOUS PAGE FOR YOUR ROUGH WORK.

Student No.: ______________________

B1. Jeremy is helping his friend James get his overturned car out of a ravine. Jeremy has attached a cable to the car, which is lying on its side in the ravine. The other end of the cable is attached to a winch on the front of Jeremy's vehicle. Jeremy's vehicle is braked solidly so it cannot move. The side of the ravine ~~it~~ is at an angle of 57.0° to the horizontal. The mass of the car is 1895 kg. When the winch is ~~turned on~~, the cable pulls the overturned car up the side of the ravine.



(a) Draw a free-body diagram of the forces on the car as it is being pulled by the cable. (*3 marks*)



(b) When the tension in the cable is 1.90×10^4 N, the car is pulled up the side of the ravine at a constant speed. Calculate the coefficient of kinetic friction between the car and the side of the ravine. (*4 marks*)

Constant speed in a straight line $\Rightarrow \vec{a} = 0$

$\therefore \sum \vec{F} = 0$

0.339

$\sum F_x = 0$

$W_x + f_{kx} + T_x = 0$

$mg\sin\theta + f_k - T = 0$

$mg\sin\theta + \mu_k N - T = 0$

$mg\sin\theta + \mu_k (mg\cos\theta) - T = 0$

$\sum F_y = 0 \Rightarrow N_y + W_y = 0$

$N - mg\cos\theta = 0$

$N = mg\cos\theta$

$$\mu_k = \frac{T - mg\sin\theta}{mg\cos\theta} = \frac{T}{mg\cos\theta} - \tan\theta = 0.339$$

(c) If the tension in the cable is increased to 2.10×10^4 N, calculate the magnitude of the acceleration of the car up the side of the ravine. (If you did not get an answer for part ~~(a)~~ (b) use a value of $\mu_k = 0.350$.) (*3 marks*)

Now $\sum F_x = ma$

1.05 m/s²

$mg\sin\theta + \mu_k (mg\cos\theta) - T = ma$

$a = g(\sin\theta + \mu_k\cos\theta) - T/m$

$a = -1.05\ \text{m/s}^2$

↑ indicates $-x$ dir'n (up the ravine wall)

Alt. answer: $-0.995\ \text{m/s}^2$

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Student No.: ____________________

g

*✓

B2. A spring gun is used to shoot a 56.0 ~~kg~~ ball horizontally. The spring has a spring constant of 28.0 N/m. When the spring gun is loaded, the spring is compressed by 0.180 m. The ball loses contact with the spring and leaves the gun when the spring is ~~still compressed by 0.120 m~~. at its uncompressed length ✓*

(a) Calculate the speed of the ball when it loses contact with the spring, leaving the gun. (*4 marks*)

4.02 m/s

4.02 m/s

$x_A = 0.180\,\text{m}$ $\quad$ $x_B = 0$

$v_A = 0$ $\quad$ $v_B = ?$

Ignoring friction in the gun barrel, $W_{nc} = 0 \Rightarrow E_A = E_B$

horizontal, so $U_{G_A} = U_{G_B}$

$$K_A^{\,0} + U_{elas_A} + U_{G_A} = K_B + U_{elas_B}^{\,0} + U_{G_B}$$

$$\tfrac{1}{2}kx_A^2 = \tfrac{1}{2}mv_B^2$$

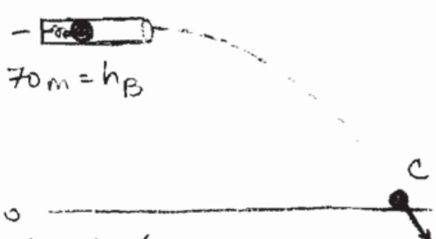
$$v_B = \sqrt{\frac{k}{m}\left(x_A^2\right)} = \boxed{4.02\,\text{m/s}}$$

(b) Calculate the speed of the ball in the instant before it hits the ground, a distance of 1.70 m below the release point (where it left the gun)? (*3 marks*) ✓

If you did not obtain an answer for (a), use 2.50 m/s.

7.03 m/s 7.03 m/s

$h_A = 1.70\,\text{m} = h_B$



$h_C = 0$

As in (a):

$$K_A^{\,0} + U_{elas_A} + U_{G_A} = K_C + U_{elas_C}^{\,0} + U_{G_C}^{\,0}$$

$$K_C = \tfrac{1}{2}kx_A^2 + mgh_A$$

$$\tfrac{1}{2}mv_C^2 = \tfrac{1}{2}kx_A^2 + mgh_A$$

$$v_C = \left(\tfrac{k}{m}x_A^2 + 2gh_A\right)^{1/2} = \boxed{7.04\,\text{m/s}}$$

Alt. Method (after leaving barrel)

$$K_B + U_{G_B} = K_C + U_{G_C}$$

$$\tfrac{1}{2}mv_B^2 + mgh_B = \tfrac{1}{2}mv_C^2$$

$$v_C = \sqrt{v_B^2 + 2gh_B}$$

$$v = \boxed{7.03\,\text{m/s}}$$

ALT: 6.29 m/s

(c) From the instant that the ball loses contact with the spring, how long does it take for the ball to reach the ground, a distance of 1.70 m below the release point (where it left the gun)? (*3 marks*)

0.589 s

Fall time is determined by vertical component of motion.

$v_{B_y} = 0$

$a_y = -9.80\,\text{m/s}^2$ (UP +ve)

$\Delta y = -1.70\,\text{m}$

$$\Delta y = v_{B_y}\Delta t + \tfrac{1}{2}a_y(\Delta t)^2$$

$$\Delta y = \tfrac{1}{2}a_y(\Delta t)^2$$

$$\Delta t = \sqrt{\frac{2\Delta y}{a_y}} = \boxed{0.589\,\text{s}}$$

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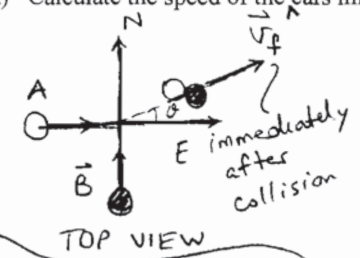
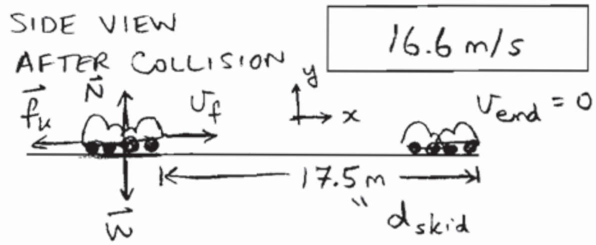
B3. A police officer is investigating the collision of two cars. Car A, of mass 1100 kg and initially moving east, had collided with Car B, of mass 1300 kg, that was initially moving north. The two cars, stuck together, had skidded at an angle of 35.6° N of E for a distance of 17.5 m before coming to rest. The coefficient of kinetic friction between the tires and the level road is 0.800.

(a) Calculate the speed of the two stuck-together cars immediately after the collision. (4 6 *marks*)





16.6 m/s

$$v_{end}^2 = v_f^2 + 2a\Delta x$$

$$0 = v_f^2 + 2a\,d_{skid}$$

$$v_f = \sqrt{-2a\,d_{skid}}$$

$$v_f = \sqrt{2\mu_k g\,d_{skid}} = 16.6\ m/s$$

$$\Sigma \vec{F}_y = 0 \Rightarrow N - W = 0 \Rightarrow N = (m_A + m_B)g$$

$$\Sigma F_x = m_{tot}a \Rightarrow -f_k = m_{tot}a$$

$$a = -f_k/m_{tot} = -\frac{\mu_k N}{m_{tot}} = -\frac{\mu_k (m_A + m_B)g}{(m_A + m_B)}$$

$$a = -\mu_k g$$

(b) Calculate the speed of Car A before the collision. If you did not obtain an answer for (a), use a value of 15.0 m/s. (3 4 *marks*)

Momentum is conserved for the collision

29.4 m/s

$$\vec{P}_{tot_i} = \vec{P}_{tot_f}$$

$$m_A\vec{v}_{A_i} + m_B\vec{v}_{B_i} = (m_A + m_B)\vec{v}_f$$

East Components:

$$m_A v_{A_i} + 0 = (m_A + m_B)v_f\cos\theta$$

$$v_{A_i} = \frac{(m_A + m_B)v_f\cos\theta}{m_A} = 29.4\ m/s$$

ALT: 26.6 m/s

(c) Calculate the speed of Car B before the collision. If you did not obtain an answer for (a), use a value of 15.0 m/s. (*3 marks*)

North Components:

17.8 m/s

$$0 + m_B v_{B_i} = (m_A + m_B)v_f\sin\theta$$

$$v_{B_i} = \frac{(m_A + m_B)v_f\sin\theta}{m_B}$$

$$v_{B_i} = 17.8\ m/s$$

ALT: 16.1 m/s

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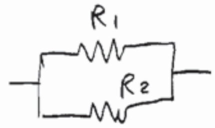
 Student No.: ______________________

B4.

(a) Calculate the equivalent resistance of the parallel combination of a 47.2 Ω resistor and a 56.1 Ω resistor. (*2 marks*)



25.6 Ω

$$R_{eq_{PAR}} = \left(\frac{1}{R_1} + \frac{1}{R_2}\right)^{-1} = 25.6\ \Omega$$

(b) This parallel resistor combination is now connected to a real battery of emf of 9.20 V and internal resistance of 4.63 Ω. Calculate the current that flows from the battery. If you did not obtain an answer for (a), use a value of 30.0 Ω. (*3 marks*)

0.304 A

$$I = \frac{\mathcal{E}}{R_{tot}} = \frac{\mathcal{E}}{r + R_{eq_{PAR}}} = \frac{9.20\text{V}}{(4.63\Omega + 25.6\Omega)} = 0.304\text{A}$$

ALT: 0.266A

(c) Calculate the amount of charge that has flowed from the battery when the circuit has been on for 1.25 minutes. If you did not obtain an answer for (b), use a value of 0.275 A. (*2 marks*)

22.8 C

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

$$\Delta q = I\Delta t = (0.304\text{A})\left(1.25\text{min} \times \frac{60\text{ s}}{\text{min}}\right) = 22.8\text{ C}$$

ALT: 20.6C

(d) Calculate the energy dissipated internally in the battery when the circuit has been on for 1.25 minutes. (*3 marks*)

32.1 J

$$P = \frac{E}{\Delta t} \Rightarrow E = P\Delta t$$

$$P_{int} = I^2 r$$

$$E_{int} = P_{int}\Delta t = I^2 r\,\Delta t = (0.304\text{A})^2(4.63\Omega)(1.25\text{min})\left(\frac{60\text{s}}{\text{min}}\right)$$

$$E_{int} = 32.1\text{ J}$$

ALT: 26.3J

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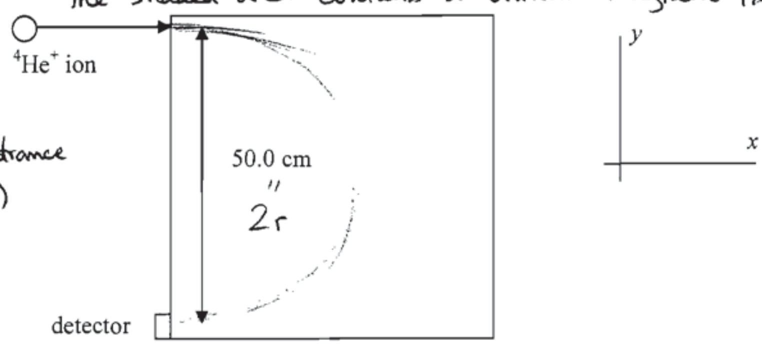
B5. You wish to make a mass spectrometer. The distance between the entrance slit and the detector is 50.0 cm, as shown in the diagram. Singly-ionised helium-4 ions of kinetic energy of 255 eV enter the spectrometer. The mass of helium-4 is 6.68×10^{-27} kg.

The shaded area contains a uniform magnetic field.



(add entrance slit)

(a) Calculate the speed of the helium-4 ions. (*3 marks*)

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

$$v = \sqrt{\frac{2K}{m}}$$

$$v = \sqrt{\frac{2(255\,eV \cdot 1.602 \times 10^{-19}\,J/eV)}{6.68 \times 10^{-27}\,kg}}$$

$$v = 1.11 \times 10^5\,m/s$$

Answer: $1.11 \times 10^5\,m/s$

(b) Which direction of magnetic field will cause the helium-4 ions to reach the detector? (*2 marks*)

Circle your choice: $+x$ $-x$ $+y$ $-y$ (out of page) into page

(c) Calculate the strength of the magnetic field required to cause the helium-4 ions to reach the detector. (*5 marks*) If you did not obtain an answer for (a) use 1.00×10^5 m/s

Note that r, radius of trajectory, is $50.0\,cm/2 = 0.250\,m$

Answer: 0.0185 T

$$\vec{v} \perp \vec{B} \Rightarrow F_B = qvB$$

$$\Sigma \vec{F} = m\vec{a}$$

$$\Sigma F_r = ma_r$$

$$qvB = \frac{mv^2}{r}$$

$$B = \frac{mv}{qr} = \frac{(6.68 \times 10^{-27}\,kg)(1.11 \times 10^5\,m/s)}{(1.602 \times 10^{-19}\,C)(0.250\,m)} = 0.0185\,T$$

ALT: 0.0167 T

continued on page 10...

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B6. The photoelectric effect is studied using a tungsten target. The work function of tungsten is 4.5 1 eV. The incident photons have energy 4.8 of 3 eV.

*

(a) Calculate the threshold frequency for ejection of photoelectrons. (*3 marks*)

$$K_{max} = hf - \phi$$

1.09×10^{15} Hz

At the threshold freq'y, $K_{max} = 0$

$$0 = hf_{th} - \phi$$

$$hf_{th} = \phi$$

$$f_{th} = \frac{\phi}{h} = \frac{4.51\,\text{eV}}{4.136 \times 10^{-15}\,\text{eV}\cdot\text{s}} = 1.09 \times 10^{15}\,\text{Hz}$$

(b) Calculate the stopping potential. (*4 marks*)

0.32V

V_{stop} is the potential req'd to just stop the electrons that have $K = K_{max}$.

i.e. $eV_{stop} = K_{max}$ (from $\Delta K = -e\Delta V$)

$$V_{stop} = \frac{K_{max}}{e} = \frac{hf - \phi}{e} = \frac{4.83\,\text{eV} - 4.51\,\text{eV}}{e}$$

$$V_{stop} = 0.32\,\text{V}$$ (but also accept 0.320 V)

(c) Explain why, according to classical physics, no threshold frequency is expected. (*3 marks*)

According to classical physics, the incident light is a wave and electrons will be ejected once they have absorbed enough energy from the light wave, regardless of the frequency.

END OF EXAMINATION