UNIVERSITY OF SASKATCHEWAN

Department of Physics and Engineering Physics

Physics 115.3 – Physics and the Universe

FINAL EXAMINATION

December 8, 2012 Time: 3 hours

NAME: SOLUTIONS MASTER STUDENT NO.: ____________

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

LECTURE SECTION (please check):

- ☐ 01 B. Zulkoskey
- ☐ 02 Dr. R. Pywell
- ☐ 03 Dr. M. Ghezelbash
- ☐ C15 F. Dean

INSTRUCTIONS:

1. This is a closed book examination.
2. The test package includes a test paper (this document), a formula sheet, 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 Hewlett-Packard HP 10s or HP 30s or Texas Instruments TI-30X series calculators, or a calculator approved by your instructor, may be used.
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 student number in the top right-hand corner of each page of the test paper.
5. Enter your name and STUDENT NUMBER on the OMR sheet.
6. The test paper, the formula sheet and the OMR sheet must all be submitted.
7. None of the test materials will be returned.

ONLY THE <u>FIVE</u> PART B QUESTIONS THAT <u>YOU INDICATE</u> WILL BE MARKED

PLEASE <u>INDICATE</u> WHICH <u>FIVE</u> 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	

continued on page 2...

PART A

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

$W = (F\cos\theta)d$

B **A1.** Which one of the following expressions gives the correct SI units for work?

(A) kg m s^{-2} [✓ (B) kg m^2 s^{-2}] (C) kg m^{-1} s^{-2} (D) kg m^2 s^{-1} (E) kg m s^{-1} $\left(\frac{kg \cdot m}{s^2}\right) \cdot m$

A **A2.** A baseball is thrown straight up. It is released at a height h above the ground. It reaches a height H above the ground before falling back down to be caught when it is again at height h above the ground. It is caught at time T after it was thrown. What is the magnitude of the baseball's average velocity during the time interval T? displacement = 0

[✓ (A) 0] (B) $\frac{H}{T}$ (C) $\frac{2H}{T}$ (D) $\frac{(H-h)}{T}$ (E) $\frac{2(H-h)}{T}$

E **A3.** A stone of mass m thrown straight up with an initial speed υ_0 reaches a maximum height h. A second stone with mass $2m$ is thrown straight up with an initial speed $2\upsilon_0$. Air resistance is negligible. What is the maximum height reached by the second stone? $v^2 = v_0^2 + 2a\Delta y$

(A) $\frac{h}{2}$ (B) h (C) $\sqrt{2}\,h$ (D) $2h$ [✓ (E) $4h$] $\Delta y = -\frac{v_0^2}{2a} = \frac{v_0^2}{2g}$

E **A4.** A baseball is thrown by the centre-fielder (from shoulder level) to home plate where it is caught (at an equal shoulder level) by the catcher. If air resistance is negligible, which statement is correct concerning the speed of the ball during its flight?

(A) Its speed is greatest at the highest point in its flight.
(B) Its speed is constant throughout its flight.
(C) Its speed is a minimum just after it leaves the fielder's hand and just before it is caught.
(D) Its speed is zero at the highest point in its flight.
[✓ (E) Its speed is a maximum just after it leaves the fielder's hand and just before it is caught.]

B **A5.** Which one of the following statements regarding momentum is <u>**FALSE**</u>?

(A) Momentum has both magnitude and direction.
[✓ (B) The magnitude of momentum is the product of mass and acceleration.] $\vec{p} = m\vec{v}$
(C) Momentum is in the same direction as velocity.
(D) Momentum is conserved during an inelastic collision.
(E) Momentum is conserved during an elastic collision.

C **A6.** As a car skids with its wheels locked trying to stop on a road covered with ice and snow, the force of friction between the icy road and the tires will usually be

(A) greater than the normal force of the road times the coefficient of static friction. f_k usually
(B) greater than the normal force of the road times the coefficient of kinetic friction. $< f_s^{max} = \mu_s n$
[✓ (C) less than the normal force of the road times the coefficient of static friction.]
(D) less than the normal force of the road times the coefficient of kinetic friction.
(E) equal to the normal force of the road times the coefficient of static friction.

D **A7.** Three projectiles of different masses are launched at different angles of elevation from the top of a building. Each projectile has the same initial kinetic energy. Which projectile has the greatest speed just as it impacts with the ground?

(A) The one launched at the highest angle of elevation. KE_i same, Δy same,
(B) The one launched at the lowest angle of elevation. $\therefore$ KE_f same
(C) The one with the highest mass.
[✓ (D) The one with the lowest mass.] $KE_f = \frac{1}{2}mv_f^2$
(E) They all will have the same speed on impact.

E **A8.** Two particles collide, one of them initially being at rest. If there are no external forces acting on the particles, is it possible for both particles to be at rest after the collision?

(A) If the collision is perfectly inelastic, then this happens. $\vec{P}_{tot_i} = \vec{P}_{tot_f}$
(B) If the collision is elastic, then this happens.
(C) This can happen sometimes if the more massive particle was at rest. $P_{tot_i} \neq 0$ so
(D) This can happen sometimes if the less massive particle was at rest.
[✓ (E) This is not possible.] $\vec{P}_{tot_f} \neq 0.$

continued on page 3...

Student No.: ____________________

A9. Two dimes are placed on a vinyl record that is rotating. Dime one is 5 cm from the axis of rotation and dime two is 10 cm from the axis of rotation. Which one of the following statements best describes the angular speeds of the dimes?

C

(A) The angular speed of dime one is twice the angular speed of dime two.
(B) The angular speed of dime two is twice the angular speed of dime one.
[✓ (C)] The angular speed of dime one is the same as the angular speed of dime two.
(D) The angular speed of dime one is four times the angular speed of dime two.
(E) The angular speed of dime two is four times the angular speed of dime one.

ω is the same throughout a rigid object (the record)

A10. An object moving in a circular path at a constant speed has an acceleration that is

A

[✓ (A)] directed towards the centre of the circular path.
(B) directed away from the centre of the circular path.
(C) directed opposite to the direction of motion.
(D) in the direction of motion.
(E) zero.

A11. A ball attached to a string is being swung in a vertical circular trajectory at a constant speed. Which one of the following statements concerning the tension in the string is correct?

B

(A) The tension is largest at the highest point of the circular trajectory.
[✓ (B)] The tension is largest at the lowest point of the circular trajectory.
(C) The tension is largest when the ball is moving upward.
(D) The tension is largest when the ball is moving downward.
(E) The tension is the same throughout the ball's motion.

$\sum \vec{F}_r = m\vec{a}_c$

At bottom, $T - mg = \frac{mv^2}{r}$

$T = \frac{mv^2}{r} + mg$

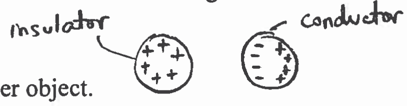
A12. The radius of the Earth is about 6400 km and the International Space Station (ISS) orbits the Earth in a nearly-circular orbit at a height of about 400 km above the Earth's surface. Compare the gravitational force of the Earth on an astronaut when she is orbiting in the ISS to her weight on the Earth's surface. The gravitational force of the Earth on her when she is orbiting is

C

(A) larger than her weight on the Earth's surface.
(B) exactly the same as her weight on the Earth's surface.
[✓ (C)] somewhat smaller than her weight on the Earth's surface.
(D) nearly zero.
(E) exactly zero.

$F_{grav} = \frac{GM_Em}{r^2} = \frac{GM_Em}{(R_E+h)^2}$

A13. A *charged* insulator and an *uncharged* conductor are near each other but not touching. Which statement is correct?



B

(A) There are no electrostatic forces on either of the objects.
[✓ (B)] There is a force of attraction on each object toward the other object.
(C) There is a force of attraction on the conductor toward the insulator but no force on the insulator.
(D) There is a force of attraction on the insulator toward the conductor but no force on the conductor.
(E) Whether there is a force of attraction or repulsion between the objects depends on the sign of the charge on the insulator.

A14. At a point A, which is a distance *d* away from a positive charge $+Q$, the electric potential is V (assuming the electric potential at an infinite distance away is zero). If now a second positive charge $+Q$ is placed halfway between the first charge and the point A, what is the new electric potential at point A?

C

(A) $2V$ (B) $2\sqrt{2}\,V$ [✓ (C)] $3V$ (D) $4V$ (E) $5V$

$V = \frac{kQ}{d}$

$V_{new} = \frac{kQ}{d} + \frac{kQ}{d/2} = 3V$

A15. It takes 10 Joules of energy to move an object, with 2.0 Coulombs of charge on it, from point A to point B. Assuming the object is at rest in its initial and final positions, there are no frictional forces acting during the move, and there is no change in gravitational potential energy between points A and B, what is the magnitude of the potential difference between points A and B?

D

(A) 20 V (B) 0.20 V (C) 10 V [✓ (D)] 5.0 V (E) zero

$\Delta PE_{el} = q\Delta V$

$\Delta V = \frac{\Delta PE_{el}}{q} = \frac{-W_{el}}{q}$ ⇗ $|\Delta V| = \frac{|-W_{el}|}{|q|} = \frac{10\,J}{2.0\,C} = 5.0\,V$

continued on page 4...

Student No.: ____________________

C

A16. Consider a point charge $+Q$. Imagine a spherical surface surrounding (and centred on) the point charge. The total electric flux through the surface is 400 N·m^2/C. If the radius of the spherical surface is now doubled, the total electric flux through this new surface is

(A) 100 N·m^2/C (B) 200 N·m^2/C [✓ (C)] 400 N·m^2/C (D) 800 N·m^2/C (E) 1600 N·m^2/C

$\Phi_E = \frac{Q_{inside}}{\varepsilon_0}$

A

A17. A metal wire of resistance R is cut into three equal pieces that are then placed side by side to form a new cable with a length equal to one-third the original length. What is the resistance of this new cable?

[✓ (A)] $\frac{1}{9}R$ (B) $\frac{1}{3}R$ (C) R (D) $3R$ (E) $9R$

$R = \rho\frac{l}{A}$

$R_{new} = \frac{\rho(l/3)}{3A}$

$R_{new} = \frac{1}{9}\frac{\rho l}{A}$

D

A18. Car batteries are often rated in ampere-hours. To what physical quantity does this rating correspond?

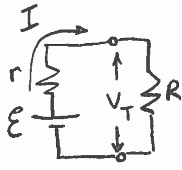
(A) current (B) power (C) energy
[✓ (D)] charge (E) emf

$\frac{charge}{time} \cdot time = charge$

B

A19. Consider a battery with an emf of ε and internal resistance of r. The battery is initially connected to a resistor circuit that has an equivalent resistance of R. If the equivalent resistance of the resistor circuit increases, what happens to the terminal voltage and the current drawn from the battery?

(A) The current decreases and the terminal voltage also decreases.
[✓ (B)] The current decreases and the terminal voltage increases.
(C) The current decreases and the terminal voltage does not change.
(D) The current increases and the terminal voltage decreases.
(E) The current increases and the terminal voltage also increases.



$I = \frac{\varepsilon}{r+R}$

$V_T = \varepsilon - Ir$

B

A20. Three resistors, each of different value, are used in a circuit with a power source supplying 12 V. For which of the following resistor combinations is the total power supplied by the source the greatest?

(A) all three resistors in series
[✓ (B)] all three resistors in parallel
(C) two of the resistors in parallel with the third resistor in series with the parallel pair
(D) two of the resistors in series with the third resistor in parallel with the series pair
(E) This cannot be found until it is known which resistor is in series with the parallel pair.

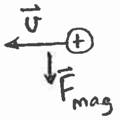
$P = \varepsilon I = \frac{\varepsilon^2}{R_{eq}}$

R_{eq} is smallest for parallel

D

A21. A proton is released such that its initial velocity is from right to left across this page. The proton's path, however, is deflected in a direction toward the bottom edge of the page due to the presence of a uniform magnetic field. What is the direction of this field?

(A) from bottom edge to top edge of the page
(B) from right to left across the page
(C) from left to right across the page
[✓ (D)] into the page
(E) out of the page

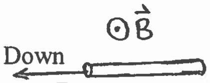


From RHR, $\vec{B}$ is into the page

A

A22. In a region of space where there is a uniform magnetic field which is directed vertically upward a horizontal wire carries a current toward the West. In which direction is the magnetic force on the wire?

[✓ (A)] North (B) South (C) East (D) West (E) Down



B

A23. The work function for a particular material is ϕ. Therefore, for photoelectrons to be emitted from the surface of this material,

(A) the wavelength of the incident light must be less than $\frac{\phi}{hc}$.

[✓ (B)] the frequency of the incident light must be greater than $\frac{\phi}{h}$.

(C) the wavelength of the incident light must be greater the $\frac{hc}{\phi}$.

(D) the frequency of the incident light must be less than $\frac{h}{\phi}$.

(E) the wavelength of the incident light must be less than $\frac{h}{\phi}$.

$KE_{max} = hf - \phi$

$hf_{min} = \phi \Rightarrow f_{min} = \frac{\phi}{h}$

$\frac{hc}{\lambda_{max}} = \phi \Rightarrow \lambda_{max} = \frac{hc}{\phi}$

continued on page 5...

$f > \frac{\phi}{h}, \lambda < \frac{hc}{\phi}$

Student No.: ____________________

A24. In the Compton effect, a photon of wavelength λ_0 and frequency f_0 scatters off an electron that is initially at rest. Which one of the following statements is correct? $\lambda - \lambda_0 = \frac{h}{m_o c}(1 - \cos\theta)$

B

- (A) The electron gains energy from the photon and therefore the scattered photon's wavelength is less than λ_0.
- [✓ (B)] The photon loses some of its energy and therefore the scattered photon's wavelength is greater than λ_0.
- (C) The photon's momentum is decreased and therefore the scattered photon's frequency is greater than f_0.
- (D) The photon is absorbed and therefore the electron acquires the energy and momentum of the photon.
- (E) The photon gains energy from the electron and therefore the scattered photon's frequency is greater than f_0.

A25. Using the Bohr model, compare the energy levels of singly-ionized helium to the energy levels of hydrogen. A helium nucleus has a charge of +2*e*. Let $E_{n,He}$ represent the energy levels of helium and let $E_{n,H}$ represent the energy levels of hydrogen.

E

(A) $E_{n,He} = \frac{1}{4} E_{n,H}$
(B) $E_{n,He} = \frac{1}{2} E_{n,H}$
(C) $E_{n,He} = E_{n,H}$
(D) $E_{n,He} = 2\, E_{n,H}$
[✓ (E)] $E_{n,He} = 4\, E_{n,H}$

$$E_n = -\frac{(13.6\text{eV})Z^2}{n^2}$$

PART B

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

FOR EACH OF YOUR CHOSEN PART B QUESTIONS ON THE FOLLOWING PAGES, GIVE THE COMPLETE SOLUTION AND ENTER THE FINAL ANSWERS IN THE BOXES PROVIDED.

THE ANSWERS MUST CONTAIN THREE SIGNIFICANT FIGURES AND THE UNITS MUST BE GIVEN.

SHOW AND EXPLAIN YOUR WORK – NO CREDIT WILL BE GIVEN FOR ANSWERS ONLY.

EQUATIONS NOT PROVIDED ON THE FORMULAE SHEET MUST BE DERIVED.

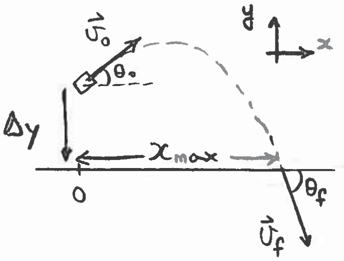
USE THE BACK OF THE PREVIOUS PAGE FOR YOUR ROUGH WORK.

continued on page 6…

Student No.: ____________________

B1. An airplane with a package attached to it is flying at a speed of 97.5 m/s at an angle of 50.0° above the horizontal. (The airplane is climbing, gaining altitude.) The ground below the plane is horizontal. When the height of the plane and package above the ground is 732 m, the package is released. You may ignore any effects due to air resistance.

(a) Calculate the time from its release until the package hits the ground. (*4 marks*)



x	y
$\Delta x = x_{max}$	$\Delta y = -732m$
$v_{0x} = v_0 \cos\theta_0$	$v_{0y} = v_0 \sin\theta_0 = (97.5 m/s)(\sin 50.0°)$
$v_x = v_{0x}$	$v_{fy} = ?$
$a_x = 0$	$a_y = -g$

$$\boxed{22.0 s}$$

$v_{0y} = 74.69 m/s$

$$\Delta y = v_{0y} t + \tfrac{1}{2} a_y t^2$$

$$-732m = (74.69 m/s)t - 4.90 m/s^2)t^2$$

$$(4.90 m/s^2)t^2 \underbrace{-(74.69 m/s)}_{b} t \underbrace{-732 m}_{c} = 0$$

a

ALT. METHOD

$$v_{fy}^2 = v_{0y}^2 + 2 a_y \Delta y$$

$$v_{fy} = -\left[(74.69 m/s)^2 + 2(-9.80 m/s^2)(-732m)\right]^{1/2}$$

$$v_{fy} = -141.2 m/s$$

$$t = \frac{v_{fy} - v_{0y}}{a_y} = 22.0s$$

$$t = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{74.69 m/s \pm \sqrt{(74.69 m/s)^2 - 4(4.90 m/s^2)(-732m)}}{2(4.90 m/s^2)}$$

$$\boxed{t = +22.0s}; \; -6.78s$$

(b) Calculate the distance along the ground, measured from directly below the point at which the package was released, to where the package hits the ground. If you did not obtain an answer for (a), use a value of 20.0 s. (*3 marks*)

$$\boxed{1.38 \times 10^3 m}$$

$$\Delta x = v_{0x} t$$

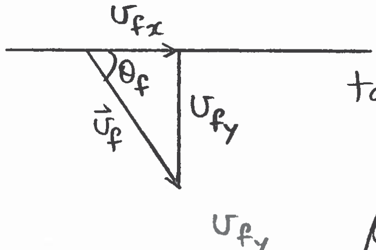
$$x_{max} = (v_0 \cos\theta_0) t$$

$$x_{max} = (97.5 m/s)(\cos 50.0°)(22.0s) = \boxed{1.38 \times 10^3 m}$$

ALT. VALUE: $1.25 \times 10^3 m$

(c) Relative to the ground, calculate the angle of the velocity vector of the package just before it hits the ground. (*3 marks*)

$$\boxed{66.1° \text{ below horizontal}}$$



$$\tan\theta_f = \frac{v_{fy}}{v_{fx}}$$

$$\theta_f = \text{invtan}\,\frac{v_{fy}}{v_{fx}} = \frac{\sqrt{v_{0y}^2 + 2 a_y \Delta y}}{v_0 \cos\theta_0} = \frac{\left[(74.69 m/s)^2 + 2(-9.80 m/s^2)(-732m)\right]^{1/2}}{(97.5 m/s)(\cos 50.0°)}$$

$$\boxed{\theta_f = 66.1° \text{ below horizontal}}$$

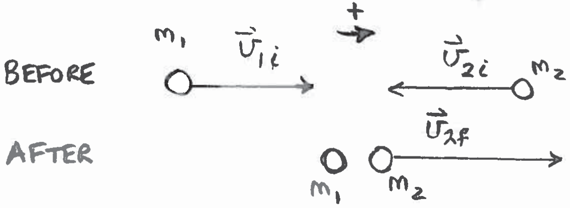
continued on page 7...

Student No.: ____________________

B2. Two blocks of masses m_1 and m_2 moving in opposite directions with the same speed υ_0 approach each other on a horizontal frictionless table and have a head-on elastic collision. As a result of the collision, m_1 stops and m_2 moves opposite to its original direction with a constant speed υ.

(a) Calculate the numerical value of the ratio of the two masses, m_1/m_2. (*5 marks*)

$\boxed{3}$



Momentum is conserved:

$$m_1\vec{v}_{1i} + m_2\vec{v}_{2i} = m_1\vec{v}_{1f} + m_2\vec{v}_{2f}$$

$$m_1 v_0 - m_2 v_0 = m_2 v$$

$$v = \left(\frac{m_1 - m_2}{m_2}\right) v_0$$

Elastic ⇒ KE is conserved:

$$KE_{tot_i} = KE_{tot_f}$$

$$\frac{1}{2}m_1 v_0^2 + \frac{1}{2}m_2 v_0^2 = \frac{1}{2}m_2 v^2$$

$$m_1 v_0^2 + m_2 v_0^2 = m_2\left[\left(\frac{m_1 - m_2}{m_2}\right) v_0\right]^2$$

$$m_1 \cancel{v_0^2} + m_2 \cancel{v_0^2} = \frac{\cancel{m_2}}{m_2^{\cancel{2}}}\left(m_1^2 - 2m_1 m_2 + m_2^2\right)\cancel{v_0^2}$$

$$m_2 m_1 + \cancel{m_2^2} = m_1^2 - 2m_1 m_2 + \cancel{m_2^2}$$

$$m_2 \cancel{m_1} = m_1^{\cancel{2}} - 2\cancel{m_1} m_2$$

$$m_2 = m_1 - 2m_2$$

$$3m_2 = m_1$$

$$\frac{m_1}{m_2} = 3$$

(b) Calculate the numerical value of the ratio of the speeds υ/υ_0. (*5 marks*)

$\boxed{2}$

From momentum conservation,

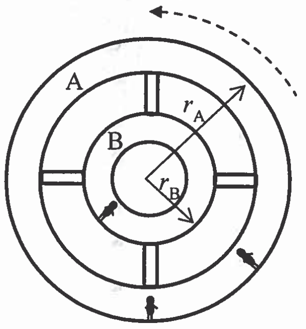
$$v = \left(\frac{m_1 - m_2}{m_2}\right) v_0$$

$$\frac{v}{v_0} = \frac{m_1 - m_2}{m_2}$$ and from (a), $m_1 = 3m_2$

$$\frac{v}{v_0} = \frac{3m_2 - m_2}{m_2} = \frac{2m_2}{m_2} = ②$$

continued on page 8...

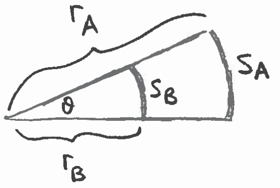
B3. A rotating space station consists of two living chambers, A and B, which have the radii $r_A = 1.10 \times 10^3$ m and $r_B = 3.20 \times 10^2$ m. As the space station rotates, in a time interval t an astronaut in chamber A is moved 2.40×10^2 m along a circular arc.



(a) Calculate how far along a circular arc an astronaut in chamber B is moved during the same time interval t. (*3 marks*)

both astronauts move through the same angle, θ.

$\boxed{69.8\,\text{m}}$



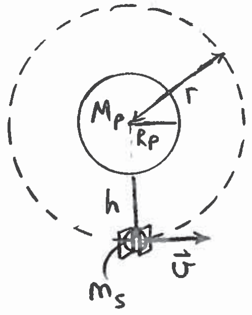
From the def'n of radian angle measure:

$$\theta = \frac{S_B}{r_B} = \frac{S_A}{r_A}$$

$$S_B = S_A\left(\frac{r_B}{r_A}\right) = (2.40\times10^2\,\text{m})\left(\frac{3.20\times10^2\,\text{m}}{1.10\times10^3\,\text{m}}\right)$$

$$\boxed{S_B = 69.8\,\text{m}}$$

(b) The space station has a mass of 5.85×10^3 kg and is in a circular orbit 4.10×10^5 m above the surface of a planet. The period of the orbit is 2.00 hours and the radius of the planet is 4.15×10^6 m. Calculate the mass of the planet. (*7 marks*)



$\boxed{1.08\times10^{24}\,\text{kg}}$

orbit radius, $r = R_p + h$

$$r = 4.15\times10^6\,\text{m} + 4.10\times10^5\,\text{m} = 4.56\times10^6\,\text{m}$$

Apply Newton II for Circular Motion:

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

$$F_{grav} = \frac{m_s v^2}{r}$$

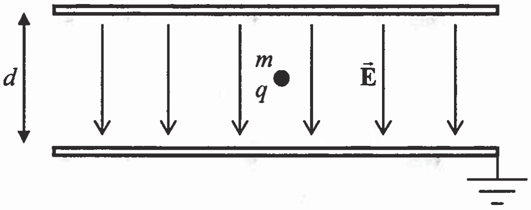
$$\frac{G M_p \cancel{m_s}}{r^{\cancel{2}}} = \frac{\cancel{m_s} v^2}{\cancel{r}} \Rightarrow M_p = \frac{r v^2}{G} \quad \text{where} \quad v = \frac{2\pi r}{T}$$

$$M_p = \frac{r\left(\frac{4\pi^2 r^2}{T^2}\right)}{G} = \frac{4\pi^2 r^3}{T^2 G} = \frac{4\pi^2(4.56\times10^6\,\text{m})^3}{\left(2.00\,\text{h}\times\frac{3600\,\text{s}}{\text{h}}\right)^2(6.67\times10^{-11}\,\text{N}\cdot\text{m}^2/\text{kg}^2)}$$

$$\boxed{M_p = 1.08\times10^{24}\,\text{kg}}$$

continued on page 9...

B4. Between two horizontal parallel plates is a uniform electric field which points downward and has a magnitude $E = 88.0 \times 10^3$ N/C. Between the plates is a small ball with mass $m = 3.50 \times 10^{-6}$ kg and charge q. The ball is motionless between the plates.



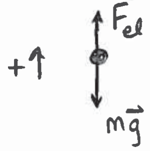
(a) What must be the sign of the charge q? Write your choice of Positive or Negative in the box. (*1 mark*)

Want $\vec{F}_{el}$ opposite to $\vec{F}_{grav}$.

Negative

$\therefore$ $\vec{F}_{el}$ opposite to $\vec{E}$, and since $\vec{F}_{el} = q\vec{E}$, q must be -ve

(b) Calculate the magnitude of the charge q. (*5 marks*)



3.90×10^{-10} C

motionless $\Rightarrow$ $\Sigma\vec{F} = 0$

$$F_{el} - mg = 0$$

$$|q|E = mg$$

$$|q| = \frac{mg}{E} = \frac{(3.50\times10^{-6}\,\mathrm{kg})(9.80\,\mathrm{m/s^2})}{88.0\times10^{3}\,\mathrm{N/C}} = \boxed{3.90\times10^{-10}\,\mathrm{C}}$$

(c) If the separation between the plates is $d = 10.5$ mm, calculate the magnitude of the potential difference between the plates that is necessary to create the electric field. (*3 marks*)

924V

$$\Delta V = -E_x \Delta x$$

$$|\Delta V| = E \cdot d$$

$$|\Delta V| = (88.0\times10^{3}\,\mathrm{N/C})\left(10.5\,\mathrm{mm} \times \frac{1\,\mathrm{m}}{1000\,\mathrm{mm}}\right)$$

$$\boxed{|\Delta V| = 924\,\mathrm{V}}$$

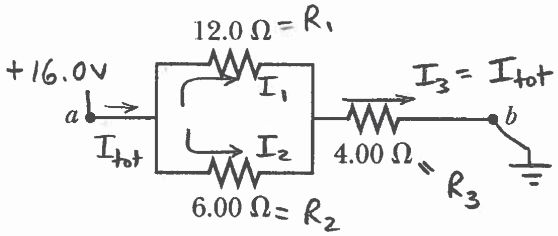
(d) If the bottom plate is grounded and considered to be at zero potential, is the potential of the top plate positive or negative? Write your choice of Positive or Negative in the box. (*1 mark*)

$\vec{E}$ points in the dir'n of decreasing potential.

Positive

continued on page 10...

B5. Consider three resistors, connected as shown:



(a) For the resistors connected as shown above, calculate the equivalent resistance between points *a* and *b*. (*4 marks*)

$\boxed{8.00\Omega}$

R_1 and R_2 are in parallel.

$$R_{eq_{12}} = \left(\frac{1}{R_1} + \frac{1}{R_2}\right)^{-1} = \left(\frac{1}{12.0\Omega} + \frac{1}{6.00\Omega}\right)^{-1} = 4.00\Omega$$

$R_{eq_{12}}$ is in series with R_3

$$\therefore R_{ab} = R_{eq_{12}} + R_3 = 4.00\Omega + 4.00\Omega = \boxed{8.00\Omega}$$

(b) If an ideal source with an emf of 16.0 V is connected across points *a* and *b*, calculate the current in each of the resistors. If you did not obtain an answer for (a), use a value of 11.0 Ω. (*6 marks*)

4.00 Ω resistor: $\boxed{2.00\text{ A}}$

6.00 Ω resistor: $\boxed{1.33\text{ A}}$

12.0 Ω resistor: $\boxed{0.667\text{ A}}$

The total current is

$$I_{tot} = \frac{\mathcal{E}}{R_{ab}} = \frac{16.0\text{V}}{8.00\Omega} = \boxed{2.00\text{A}}$$

This is the current in R_3.

The voltage drop across R_3 is $\Delta V_3 = I_3 R_3 = (2.00\text{ A})(4.00\Omega)$

$$\Delta V_3 = 8.00\text{V}$$

$\therefore$ The voltage drop across R_1 and across R_2 is

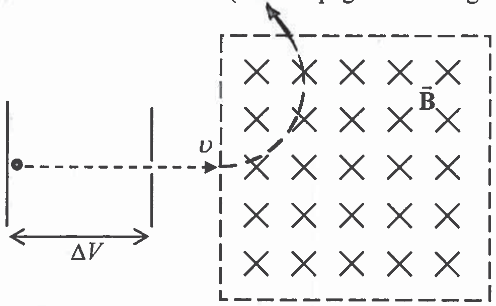
$$\Delta V_1 = \Delta V_2 = \mathcal{E} - \Delta V_3 = 16.0\text{V} - 8.00\text{V} = 8.00\text{V}$$

$$\therefore I_1 = \frac{\Delta V_1}{R_1} = \frac{8.00\text{V}}{12.0\Omega} = \boxed{0.667\text{ A}}$$

$$I_2 = \frac{\Delta V_2}{R_2} = \frac{8.00\text{V}}{6.00\Omega} = \boxed{1.33\text{A}}$$

continued on page 11...

B6. An alpha particle, which has a charge +2e and mass 6.64×10^{-27} kg, is accelerated from rest through a potential difference of magnitude $\Delta V = 5.00 \times 10^5$ V. After passing out of the accelerating potential the alpha particle has speed υ. It then passes into a region which has a uniform magnetic field directed downward (into the page in the diagram).



(a) Calculate the speed of the alpha particle, υ, as it enters the region of the magnetic field. (*4 marks*)

Energy is conserved as the α particle moves through the accelerating potential

$\boxed{6.95 \times 10^6 m/s}$

$$KE_i + PE_{el_i} = KE_f + PE_{el_f}$$

$$0 - PE_{el_f} + PE_{el_i} = KE_f$$

$$\frac{1}{2}mv_f^2 = -\Delta PE_{el}$$

$$\frac{1}{2}mv_f^2 = -q\Delta V$$

$$v_f = \sqrt{\frac{2(-q)(\Delta V)}{m}} = \sqrt{\frac{2(-2(+1.602\times10^{-19}C))(-5.00\times10^5 V)}{6.64\times10^{-27} kg}}$$

$$v_f = \boxed{6.95\times10^6 m/s}$$

(b) Sketch, on the diagram above, the path of the alpha particle in the region of magnetic field. (*2 marks*)

upward curving circular arc, at most a semi-circle.

(c) Calculate the magnitude of the magnetic field needed so that the radius of the alpha particle's trajectory is 15.0 cm. (If you did not get an answer for (a), use a speed of 5.00×10^6 m/s.) (*4 marks*)

Since $\vec{v} \perp \vec{B}$, uniform circular motion

$\boxed{0.960 T}$

$$\sum F_r = ma_c$$

$$q\cancel{v}B \sin 90° = \frac{mv^{\cancel{2}}}{r} \Rightarrow B = \frac{mv}{qr}$$

$$B = \frac{(6.64\times10^{-27} kg)(6.95\times10^6 m/s)}{2(1.602\times10^{-19}C)(0.150 m)} = \boxed{0.960 T}$$

END OF EXAMINATION