PART I
Total Value: 50%

Instructions: Shade the letter of the correct answer on the computer scorable answer sheet provided.

1. Which illustrates projectile motion?

(A) driving a car around a banked curve
(B) dropping a rock from a building
✓ (C) juggling
(D) running

2. A ball kicked from the ground at 12.0 m/s and 28° from the horizontal, returns to the ground in 5.0 s. What is the ball's speed just before it hits the ground?

(A) 0 m/s
(B) 5.6 m/s
(C) 11 m/s
✓ (D) 12 m/s

3. If a ball is thrown at an angle of 35° from the ground, at a speed of 8.0 m/s, what is the magnitude of the vertical component of the initial velocity?

✓ (A) 4.6 m/s
(B) 5.6 m/s
(C) 6.6 m/s
(D) 8.0 m/s

4. A ball is thrown horizontally at 10.0 m/s. If it hits the ground 2.00 s later, what is the magnitude of the x-component of its velocity just before it hits the ground?

(A) 0 m/s
✓ (B) 10.0 m/s
(C) 20.0 m/s
(D) 30.0 m/s

5. If a coin is pushed horizontally from a 1.2 m high table and lands 0.75 m from the base, what was the speed at which it left the table?

(A) 0.38 m/s
✓ (B) 1.5 m/s
(C) 1.9 m/s
(D) 3.0 m/s

6. What is the magnitude of the acceleration for the object below if F_f = 1.0 N?

(A) 0.80 m/s^2
✓ (B) 1.3 m/s^2
(C) 1.5 m/s^2
(D) 1.8 m/s^2

7. Which represents the range for a projectile launched horizontally with velocity, v, from height, h?

(A) $v \sin\theta\sqrt{\frac{h}{4.9}}$

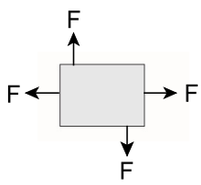
(B) $-v \cos\theta\sqrt{\frac{h}{4.9}}$

✓ (C) $v\sqrt{\frac{h}{4.9}}$

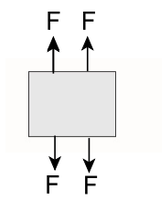
(D) $v\left(\frac{h}{4.9}\right)$

8. For which free body diagram is $\vec{F}_{net} \neq 0$?

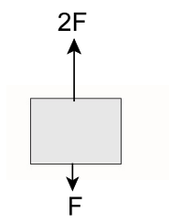
(A)



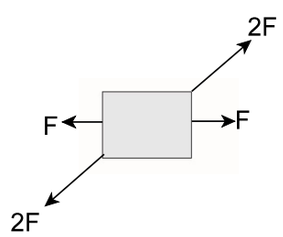
(B)



✓ (C)



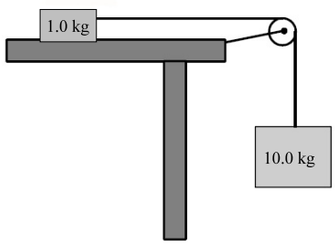
(D)



9. What is the speed of a car as it travels around a circle with a radius of 3.4×10^2 m if its centripetal acceleration is 3.8 m/s^2?

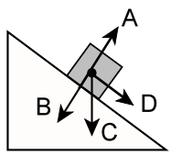
(A) 11 m/s
✓ (B) 36 m/s
(C) 130 m/s
(D) 1300 m/s

10. The diagram below shows a 1.0 kg object connected to a 10.0 kg mass. Assuming the force of friction is 10.0 N, what is the acceleration of the system?



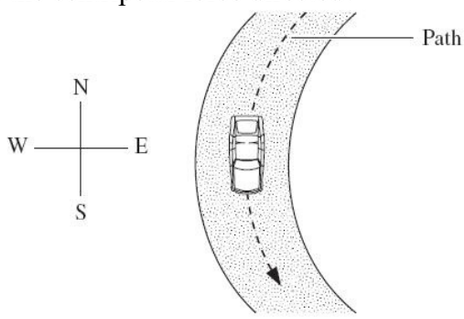
✓ (A) 8.0 m/s^2
(B) 8.8 m/s^2
(C) 8.9 m/s^2
(D) 9.8 m/s^2

11. The free body diagram below represents an object sliding down a frictionless surface. Which vector represents the force of gravity?



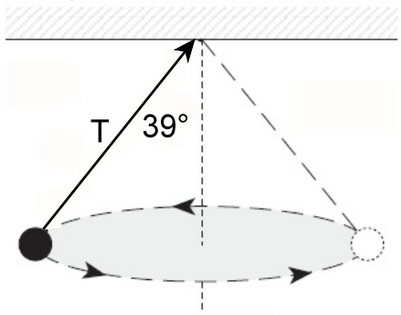
(A) A
(B) B
✓ (C) C
(D) D

12. In the diagram below, a car is moving south at a constant speed along a circular path. In which direction is the centripetal force directed?



✓ (A) east
(B) north
(C) south
(D) west

13. The diagram below shows a 3.0 kg ball, suspended by a string, undergoing uniform circular motion. If the speed of the ball is 3.1 m/s and the radius of the circle is 1.2 m, what is the tension in the string?



(A) 31 N
✓ (B) 38 N
(C) 62 N
(D) 76 N

14. By which factor does the centripetal force change if a car goes around a curve at ⅓ of its original speed?

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

✓ (B) $\frac{1}{9}$

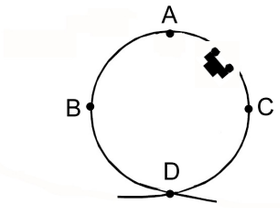
(C) 3

(D) 9

15. Tires on a moving bicycle make two complete rotations in 0.18 s. If the radius of the tires is 0.42 m, how fast is the bicycle travelling?

(A) 0.47 m/s
(B) 2.3 m/s
(C) 15 m/s
✓ (D) 29 m/s

16. If the vehicle below completes the loop, at which point is the normal force lowest?



✓ (A) A
(B) B
(C) C
(D) D

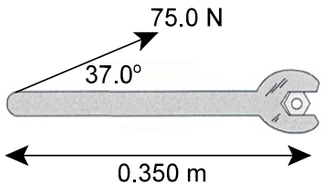
17. As the radius of a merry-go-round doubles, by what factor does the magnitude of the centripetal force acting on a passenger change?

(A) double
✓ (B) half
(C) triple
(D) quadruple

18. Which best defines torque?

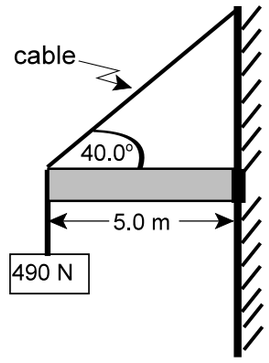
(A) $\mathbf{J/m}$
(B) $\mathbf{kg \cdot m/s^2}$
✓ (C) $\mathbf{N \cdot m}$
(D) $\mathbf{N \cdot m^2}$

19. How much torque is produced by a force of 75.0 N exerted on the wrench below?



✓ (A) 15.8 N·m
(B) 21.0 N·m
(C) 161 N·m
(D) 214 N·m

20. What is the tension in the cable below if a 490 N object is suspended from the end of a 5.0 m long uniform beam? Assume the beam is massless.



(A) 490 N
(B) 590 N
✓ (C) 760 N
(D) 4800 N

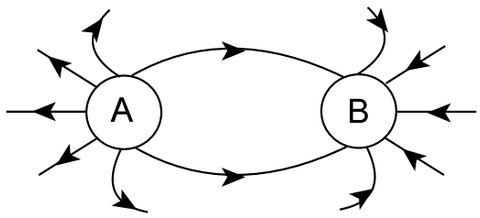
21. What happens to a grounded object when it is charged by induction with a positively charged rod?

(A) gains electrons from the rod
✓ (B) gains electrons from the ground
(C) loses electrons from the rod
(D) loses electrons from the ground

22. If two objects with the same mass and charge are brought near each other, which best describes their fields?

	Gravitational	Electric
(A)	attractive	attractive
✓ (B)	attractive	repulsive
(C)	repulsive	attractive
(D)	repulsive	repulsive

23. What are the charges on sphere A and B below?



	A	B
(A)	negative	negative
(B)	negative	positive
✓ (C)	positive	negative
(D)	positive	positive

24. If the charges on each of two identical spheres are doubled and the distance between the charges is halved, by what factor is the electrostatic force increased?

(A) 2
(B) 4
(C) 8
✓ (D) 16

25. What is the charge on an object that experiences a 5.0 N force in a 50.0 N/C electric field?

✓ (A) 0.10 C
(B) 0.20 C
(C) 2.0 C
(D) 10.0 C

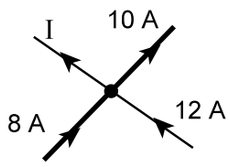
26. By which process does a solar calculator get its energy?

✓ (A) photo electricity
(B) piezo-electricity
(C) thermoelectricity
(D) voltaic cell

27. Wire A has a resistance of 12 Ω. Wire B, of the same material, is twice as long and has half the cross-sectional radius of wire A. What is the resistance of wire B?

(A) 1.5Ω
(B) 12 Ω
(C) 48 Ω
✓ (D) 96 Ω

28. What is the value of I in the circuit junction below?



(A) 6 A
✓ (B) 10 A
(C) 14 A
(D) 30 A

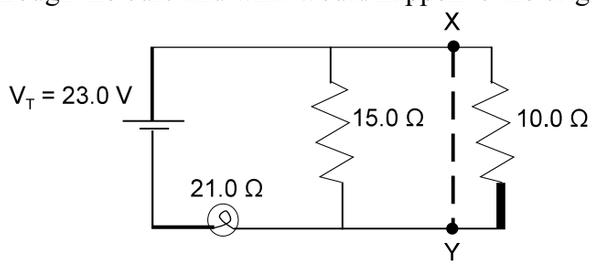
29. Who proposed that around any closed path, the sum of the voltage rises is equal to the sum of the voltage drops?

(A) Coulomb
✓ (B) Kirchoff
(C) Ohm
(D) Voltaire

30. How many electrons are transferred in a 10.0 A current that runs for 3.0 s?

(A) 3.0×10^{1}
✓ (B) 1.9×10^{20}
(C) 6.2×10^{19}
(D) 3.3×10^{31}

31. If a copper wire was connected across points X and Y in the circuit below, what would be the current through the bulb and what would happen to the brightness of bulb?



		Current (A)	Brightness
	(A)	0.64	dimmer
	(B)	0.64	brighter
	(C)	1.10	dimmer
✓	(D)	1.10	brighter

32. If four 20 Ω resistors are connected in parallel, what is the equivalent resistance?

✓ (A) 5 Ω
(B) 10 Ω
(C) 20 Ω
(D) 80 Ω

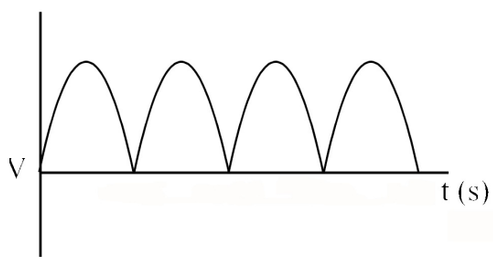
33. If a 1.2×10^3 W hair dryer has a 10.0 Ω resistance, how much current will it draw?

(A) 0.091 A
✓ (B) 11 A
(C) 12 A
(D) 120 A

34. If a 2.0 kW heater operates for 10.0 hours, what is the cost of operating the heater if the rate is $0.11/kWh?

✓ (A) $2.20
(B) $0.22
(C) $1.10
(D) $182

35. The graph below shows the output from a generator. What is true of the generator?



(A) AC with multiple loops
(B) AC with a single loop
(C) DC with multiple loops
✓ (D) DC with a single loop

36. In which direction does the current-carrying conductor below experience a magnetic force?

✓ (A) down
(B) left
(C) right
(D) up

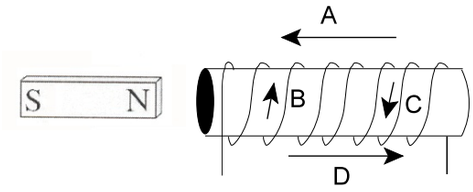
37. What is the magnetic field strength in air, 0.15 m from a straight conductor, carrying an 11 A current?

(A) 2.7×10^{-9} T
(B) 5.5×10^{-7} T
✓ (C) 1.5×10^{-5} T
(D) 1.2×10^{1} T

38. If a 1.0 m wire, perpendicular to a 0.40 T uniform magnetic field, is carrying a 10.0 A current, what is the magnitude of its force?

(A) −4.0 N
(B) 0 N
✓ (C) 4.0 N
(D) 8.0 N

39. The bar magnet below enters a solenoid from the left. What will be the direction of the induced current in the solenoid?



(A) A
(B) B
✓ (C) C
(D) D

40. A proton is shot into a magnetic field at a right angle with a speed of 2.0×10^{5} m/s. What is the strength of a magnetic field required to keep the proton in a horizontal circular orbit, if the radius of the orbit is 1.0 cm?

(A) 1.1×10^{-6} T
(B) 1.1×10^{-4} T
(C) 2.1×10^{-3} T
✓ (D) 2.1×10^{-1} T

41. What is the energy of a single photon in a beam of x-rays with $\lambda = 2.6$ nm?

(A) 1.7×10^{-42} J
(B) 1.1×10^{-23} J
✓ (C) 7.6×10^{-17} J
(D) 4.8×10^{2} J

42. If the wavelength of light is 250 nm, what is the maximum kinetic energy of the photoelectrons in a metal that has a work function of 4.5 eV?

(A) 0 eV
(B) 0.37 eV
✓ (C) 0.47 eV
(D) 0.53 eV

43. If a photon has a 6.6×10^{-32} m wavelength, what is its momentum?

(A) 4.4×10^{-65} kg·m/s
✓ (B) 1.0×10^{-2} kg·m/s
(C) 1.0×10^{-1} kg·m/s
(D) 2.4×10^{12} kg·m/s

44. What is the change in energy when an electron drops from $n = 3$ to $n = 1$?

(A) 1.5 eV
✓ (B) 12.1 eV
(C) 13.6 eV
(D) 15.1 eV

45. If an electron has a speed of 1.0×10^4 m/s, what potential difference must be applied to stop the electron?

(A) 4.6×10^{-23} V
(B) 8.4×10^{-20} V
✓ (C) 2.8×10^{-4} V
(D) 5.2×10^{-1} V

46. Which type of decay emits a helium nucleus?

✓ (A) α
(B) β^-
(C) β^+
(D) γ

47. Which best describes X in the reaction, ${}^{218}_{84}\mathrm{Po} \rightarrow {}^{214}_{82}\mathrm{Pb} + \mathrm{X} + \gamma$?

	Atomic Number	Mass Number
✓ (A)	2	4
(B)	4	2
(C)	166	432
(D)	432	166

48. Which process involves making one helium atom from four hydrogen atoms?

(A) fission
✓ (B) fusion
(C) gamma radiation
(D) radioactive dating

49. What is the wavelength of a charged particle, q, which is accelerated from rest through a potential difference, V?

✓ (A) $\frac{hc}{Vq}$

(B) $\frac{hcq}{V}$

(C) $\frac{hcV}{q}$

(D) $\frac{Vq}{hc}$

50. What is the function of the control rods in a fission reactor?

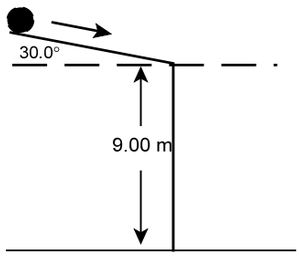
✓ (A) absorbs slow neutrons
(B) increases the speed of neutrons
(C) prevents heat loss from the core
(D) transmits gamma rays

PART II
Total Value: 50%

Instructions: Complete all items in this section. Your responses must be clearly presented in a well organized manner with proper use of units, formulae and significant figures where appropriate.

Value

4% 51.(a) A ball rolls off an incline at 20.0 m/s, 30.0° as shown in the diagram below. At what horizontal distance from the wall will the ball hit the ground?



0.5 marks $v_{1x} = (20.0\text{m/s})(\cos 30^\circ) = 17.32\text{m/s}$

0.5 marks $v_{1y} = -(20.0\text{m/s})(\sin 30^\circ) = -10.0\text{m/s}$

Find the time:

0.5 marks $d_y = v_{1y}t + \frac{1}{2}a_y t^2$

0.5 marks $-9.00\text{m} = (-10.0\text{m/s})t + \frac{1}{2}(-9.80\text{m/s}^2)t^2$

$-9.00 = -10.0t - 4.9t^2$

0.5 marks $4.9t^2 + 10t - 9 = 0$

$$t = \frac{-10.0 \pm \sqrt{100 - 4(4.9)(-9.00)}}{9.80}$$

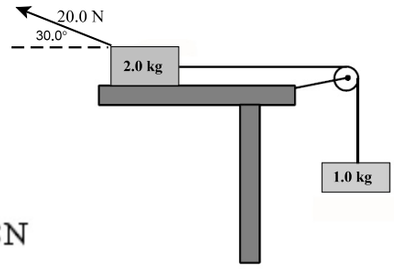
$$t = \frac{-10.0 \pm \sqrt{276.4}}{9.80}$$

0.5 marks $t = 0.676\text{s}$

Range:

1 mark $d_x = v_x t = (17.32\text{m/s})(0.676\text{s}) = 11.7\text{m}$

3% (b) A 20.0 N force is applied to a 2.0 kg mass at 30.0° to the horizontal. If friction is negligible, what is the tension in the string?



$$a = \frac{F_{net}}{m} = \frac{W_{1.0kg} - F_{x(2.0kg)}}{m_{total}}$$

where:

0.5 marks $W_{1.0kg} = mg = (1.0\text{kg})(9.80\text{m/s}^2) = 9.8\text{N}$

0.5 marks $F_{x(2.0kg)} = (20.0\text{N}\cos 30^\circ) = 17.32\text{N}$

Thus:

1 mark $a = \frac{F_{net}}{m_{total}} = \frac{17.32\text{N} - 9.8\text{N}}{3.0\text{kg}} = 2.5\text{m/s}^2$

To find tension, look at the 1.0 kg box only:

$T - W = F_{net}$

0.5 marks $T = W + ma$

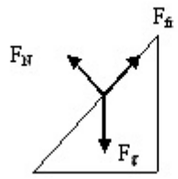
$T = 9.8\text{N} + (1.0\text{kg})(2.51\text{m/s}^2)$

0.5 marks $T = 12.3\text{N}$

4% 51.(c) A skier starts from rest and begins descending a 30.0° slope. The coefficient of kinetic friction is 0.10.

(i) What is the acceleration of the skier? Include a free body diagram.

1 mark



1 mark $$a = \frac{F_{net}}{m} = \frac{F_{gx} - F_{fr}}{m} = \frac{mg\sin 30.0^\circ - \mu_k mg\cos 30.0^\circ}{m}$$

Cancelling m's:

0.5 marks $$a = 9.80\sin 30.0^\circ - (0.10)9.80\cos 30.0^\circ$$

0.5 marks $$a = 4.1 m/s^2$$

(ii) How far down the slope will the skier travel in 10.0 s?

0.5 marks $$d = v_1 t + \frac{1}{2}at^2$$

$$v_1 = 0 m/s$$

$$d = \frac{1}{2}(4.05 m/s^2)(10.0 s)^2$$

0.5 marks $$d = 2.0 x 10^2 m$$

3% (d) What is the maximum speed a car can travel around a curve on a flat road if the radius of the curve is 1.20×10^2 m and the coefficient of static friction between the tires and road is 0.25?

0.5 marks $$F_{fr} = F_c$$

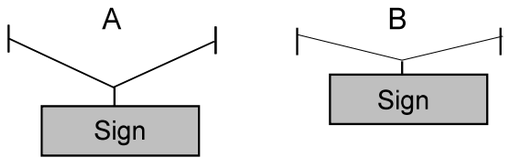
0.5 marks $$\mu_s mg = \frac{mv^2}{r}$$

$$v^2 = \mu_s gr$$

1 mark $$v = \sqrt{\mu_s gr} = \sqrt{(0.25)(9.80 m/s^2)(1.20 x 10^2 m)} = 17 m/s$$

1 mark **science communication skills**

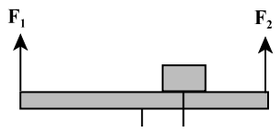
2% 51.(e) Explain, using principles of physics, which design below would best hold a sign?



1 mark For each sign, $T = \frac{W}{2\sin\theta}$.

1 mark In diagram A the angle made to the horizontal is larger making the tension smaller. In diagram B there would be more stress on the cables holding up the sign.

4% (f) A 75 kg box is placed 0.60 m from the right edge of a uniform 25 kg table that is 2.0 m long. How much force is required (F_1 and F_2) to lift the table from both ends?



Choose the pivot at F_1.

$\tau_{F2} = \tau_{box} + \tau_{table}$

1.5 marks

$F_2(2.0\text{m}) = (75\text{kg})(9.80\text{m/s}^2)(2.0\text{m} - 0.60\text{m}) + (25\text{kg})(9.80\text{m/s}^2)(1.0\text{m})$

$2.0F_2 = 1274$

0.5 marks

$F_2 = 637\text{N} = 6.4\text{x}10^2\text{ N}$

Then use the idea that F_{net}=0 to find F_1.

$F_1 + F_2 = F_{table} + F_{box}$

0.5 marks

$F_1 = F_{table} + F_{box} - F_2$

1 mark

$F_1 = (25\text{kg})(9.80\text{m/s}^2) + (75\text{kg})(9.80\text{m/s}^2) - 637\text{N}$

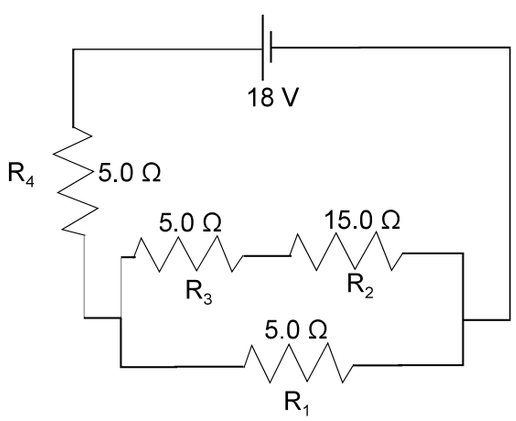
$F_1 = 343\text{N} = 3.4\text{x}10^2\text{N}$

0.5 marks

2% 52.(a) A charged rod is brought near a negatively charged electroscope causing the leaves to collapse. Explain what charge is on the rod.

The charge on rod A must be positive. A positively charged rod would attract electrons from the bottom of the electroscope, making the leaves less negative than before. Thus they collapse from their initial position.

3% 52.(b) For the circuit shown in the diagram below, calculate:



2% (i) the total resistance;

The 5.0 Ω and 15.0 Ω resistors are in series, so the resistance in that series branch is 20.0 Ω. Then the parallel branch has a total resistance given by:

1 mark $\frac{1}{R_{parallel}} = \frac{1}{20.0} + \frac{1}{5.0}$

0.5 marks $R_{parallel} = 4.0\Omega$

0.5 marks Then the total resistance for the circuit is 4.0 Ω + 5.0 Ω = 9.0 Ω.

4% (ii) the current through each resistor;

The total current out of the source is given by:

$I = \frac{V}{R} = \frac{18V}{9\Omega} = 2.0A$

1 mark Since I_4 receives all this current, I_4=2.0 A.

The voltage across the parallel branch is given by:

1 mark $V = IR = (2.0A)(4.0\Omega) = 8.0V$

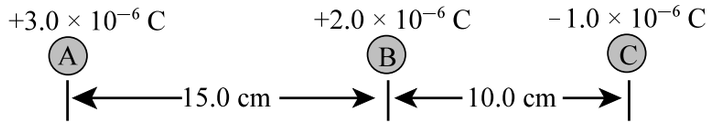
Then,

1 mark $I_1 = \frac{V_1}{R_1} = \frac{8.0V}{5.0\Omega} = 1.6A$

For the 20.0 Ω branch:

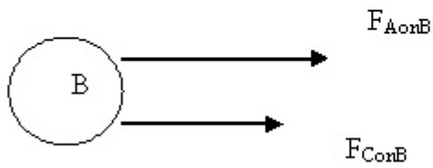
1 mark $I_2 = I_3 = \frac{V}{R} = \frac{8.0V}{20.0\Omega} = 0.40A$

3% 52.(c) The diagram below shows three charged objects. What is the net electrostatic force on B due to A and C?



0.5 marks $F_{AonB} = \frac{kq_A q_B}{r_{AB}^2} = \frac{(9.0x10^9 \frac{N \cdot m^2}{C^2})(3.0x10^{-6} C)(2.0x10^{-6} C)}{(0.15m)^2} = 2.4N(repulsive)$

0.5 marks $F_{ConB} = \frac{kq_C q_B}{r_{CB}^2} = \frac{(9.0x10^9 \frac{N \cdot m^2}{C^2})(-1.0x10^{-6} C)(2.0x10^{-6} C)}{(0.10m)^2} = -1.8N(attractiv$

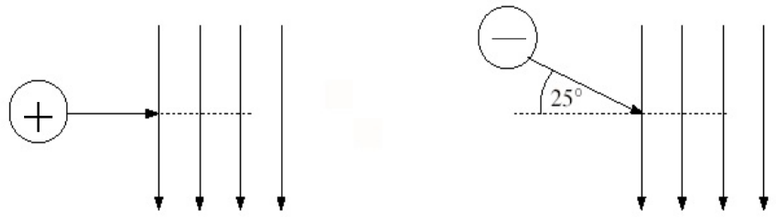


1 mark So,

$F_{net} = 2.4N + 1.8N = 4.2N(right)$

1 mark **science communication skills**

2% (d) The diagram below shows a proton and an electron entering identical uniform magnetic fields. Describe two differences between the motions of the proton and electron after they enter the magnetic fields.



i) The direction of deflection. The proton will be deflected into the page while the electron will be deflected out of the page.
ii) The shape of the path. The proton will take a circular path while the electron's path will be a spiral shape.

3% 52.(e) An 9.80×10^{-16} kg oil drop is suspended between two horizontal parallel charged plates. If the electric field strength is 2.0×10^{4} N/C, how many electrons are on the oil drop?

0.5 marks $F_g = F_{elec}$

0.5 marks $mg = \varepsilon Q$

1 mark
$$Q = \frac{mg}{\varepsilon} = \frac{(9.80\text{x}10^{-16}\,\text{kg})(9.80\,\text{m/s}^2)}{2.0\text{x}10^{4}\,\text{N/C}} = 4.802\text{x}10^{-19}\,\text{C}$$

Then :

$Q = Ne$

1 mark
$$N = \frac{Q}{e} = \frac{4.802\text{x}10^{-19}\,\text{C}}{1.6\text{x}10^{-19}\,\text{C}} = 3.0\,\text{electrons}$$

4% (f) A kitchen has two 120 W light bulbs, a 450 W coffee maker, and a 1280 W deep fryer operating on the same 120 V circuit at the same time. The circuit is protected by a 20.0 A fuse. What will happen if a 1200 W dishwasher is switched on within the same circuit? Use calculations to justify your answer.

With the two light bulbs, the coffee maker and the deep fryer operating at the same time:

1 mark
$$I = \frac{P_{total}}{V} = \frac{120\text{W} + 120\text{W} + 450\text{W} + 1280\text{W}}{120\text{V}} = 16.4\text{A}$$

When the dishwasher is added, the current becomes:

1 mark
$$I = \frac{P_{total}}{V} = \frac{120\text{W} + 120\text{W} + 450\text{W} + 1280\text{W} + 1200\text{W}}{120\text{V}} = 26.4\text{A}$$

2 marks So without the dishwasher the current does not exceed 20.0 A and the fuse will not blow. With the dishwasher however, the fuse will exceed 20.0 A and will blow.

Value

3% 53.(a) The photocell in a movie projector contains sodium, which has a work function (W_o) of 2.28 eV. Explain, using calculations, why the photoelectric effect does not occur when the photocell is illuminated by a light with λ = 650 nm.

2 marks
$$E = \frac{hc}{\lambda} = \frac{(6.626\text{x}10^{-34}\,\text{J}\cdot\text{s})(3.00\text{x}10^{8}\,\text{m/s})}{6.50\text{x}10^{-7}\,\text{m}} = 3.1\text{x}10^{-19}\,\text{J} = 1.91\text{eV}$$

1 mark Since the photon energy is less than the work function (2.28 eV) the incoming light does not have enough energy to liberate electrons from the metal, and the photoelectric effect will not occur.

3% (b) A radium isotope, $^{226}_{88}\text{Ra}$, undergoes alpha decay to produce an isotope of radon. The chemical symbol for radon is Rn.

(i) Write the decay equation showing the mass number and atomic number of all products.

1 mark
$$^{226}_{88}\text{Ra} \rightarrow {}^{222}_{86}\text{Rn} + {}^{4}_{2}\text{He}$$

(ii) How much energy is released by the alpha decay given the masses below?

Particle	Mass (u)
radium isotope	226.0244
radon isotope	222.0164
alpha	4.0026

1 mark
$$\Delta m = 226.0244\text{u} - (222.0164\text{u} + 4.0026\text{u}) = 0.0054\text{u}$$

Then,

1 mark
$$E = (0.0054\text{u})(931.5\text{MeV/u}) = 5.03\text{MeV}$$

4% 53.(c) Strontium - 82 has a half-life of 25.0 days. If a sample originally contained 140 g of strontium - 82, in how many days will the sample contain 7.5 g of the isotope?

$$N = N_o\left(\frac{1}{2}\right)^{\frac{t}{T_{\frac{1}{2}}}}$$

1 mark
$$7.5\text{g} = 140\text{g}\left(\frac{1}{2}\right)^{\frac{t}{25.0}}$$

$$\frac{7.5\text{g}}{140\text{g}} = \left(\frac{1}{2}\right)^{\frac{t}{25.0}}$$

0.5 marks
$$0.0536 = \left(\frac{1}{2}\right)^{\frac{t}{25.0}}$$

0.5 marks
$$\log 0.0536 = \log\left(\frac{1}{2}\right)^{\frac{t}{25.0}}$$

$$\frac{t}{25.0} = \frac{\log 0.0536}{\log 0.5}$$

0.5 marks
$$\frac{t}{25.0} = 4.2216$$

0.5 marks
$$t = 105.5\text{days} = 1.1\text{x}10^{2}\,\text{days}$$

1 mark **science communication skills**