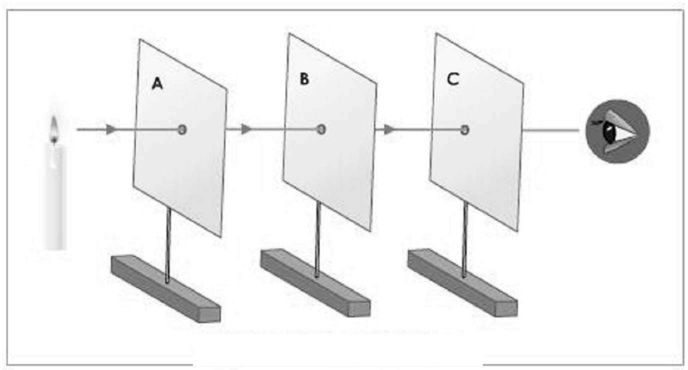
2013 VSSC Physics Exam MARKING SCHEME

Question 1: Properties of Light

a.

(i) A student placed a circular card behind a light source at B and observed a circular shadow on a wall at S.

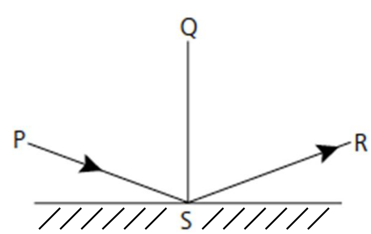


Rectilinear Propagation ***(1 mark)***

(ii) Give a definition of the property.

Rectilinear propagation says that light radiates and travels from a source in straight lines. Thus the light rays seen in the diagram travel in a straight line from B to S and the shadow formed is larger than the original object. ***(1 mark)***

b. In the diagram, a ray is directed at the surface of a mirror. Place the correct letter(s) next to the term given below



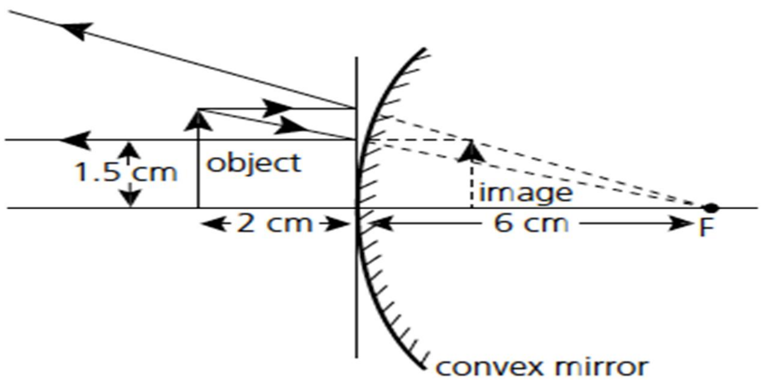
(i) Reflected ray (*1 mark)*
R

(ii) Normal to the mirror surface
QS (*1 mark)*

(2 marks)

c. A convex mirror has a focal length of 6.0 cm. An object of height 1.5 cm is placed 2.0 cm in front of the mirror.

(i) Draw an accurate ray diagram to find the position of the image.



1 for correct mirror
2 for any two correct rays for the image
2 for object and distance
1 for correct orientation of image
1 mark for focal length = 6cm

(7 marks)

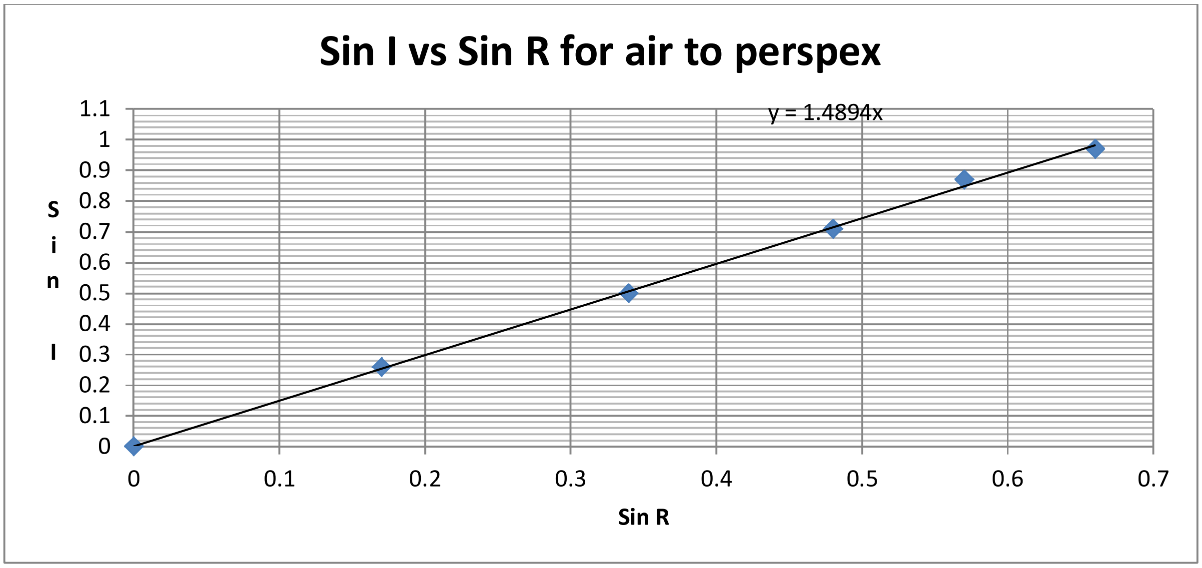
(ii) Calculate the magnification.
M = Hi/Ho
= 1.0 cm/1.5 cm
= 0.67
2 marks*, 1 for correct equation, but Ho/Hi* ***(2 marks)***

d. An experiment is carried out where a single ray of light passes from air into perspex. The angle of incidence is varied and the angle of refraction measured in each case. The results are tabled below:

I	R	Sin I	Sin R
0	0	0	0
15	10	0.17	0.26
30	20	0.34	0.50
45	29	0.48	0.71
60	35	0.57	0.87
75	41	0.66	0.97

(i) Plot a graph on the squared space below of sin I against sin R and calculate the slope

1 mark for: Correct labels and units
Scale
Line of best fit
Slope = 1.49



(4 marks)

(ii)Using either the data or your graph, calculate the angle of reflection if the angle of incidence is 33^o.

sin 33 = 0.54
From the graph: sin R = 0.36

∴R = 21.1° ***(1 mark)***

(iii) What does the slope of the graph represent?

The slope of the graph represents the refractive index of Perspex with respect to air. In this case it is 1.49. ***(1 mark)***

e. An object placed 5.0cm in front of a converging lens of focal length 8.0cm.

(i) Calculate the Position of the image.

u = 5.0cm

f = 8.0cm

Using the lens formula:

1/f = 1/u + 1/v

1/8 = 1/5 + 1/v

1/v = 1/8 – 1/5

1/v = -3/40

v = -13cm

or

$S_iS_o = f^2$

$S_{i} = f^2/S^o$

= 64/3 = 21.3 from focus

S_i *= 21.3 – 8*

=13.3cm **(1 mark)**

(ii) Calculate the Magnification of the image

M = -v/u

= (-40/3)/5)

M = - 8/3

M = 2.7 (absolute value. However, did not penalise for -2.7 **(1 mark)**

(iii) State three properties of the image.

a. Virtual, calculated position is negative

b. Erect, since the image is virtual

c. M is >1 so the image is magnified **(3 marks)**

Question 2: Wave Properties and Propagation

a. Define the following terms and give an example of each wave type:

(i) Transverse Wave

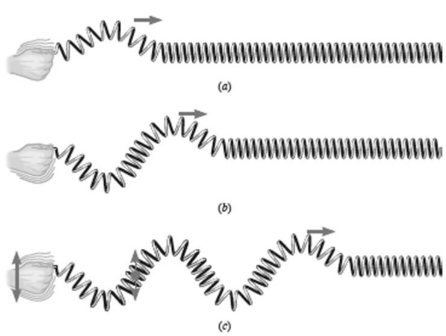


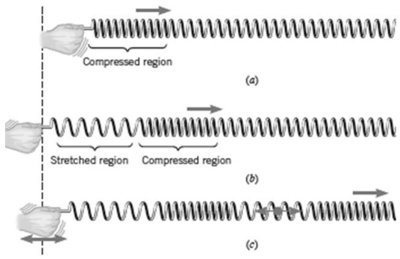
Figure 16.2 (*a*) An upward pulse moves to the right, followed by (*b*) a downward pulse. (*c*) When the end of the Slinky is moved up and down continuously, a transverse wave is produced.

A transverse wave is one in which the disturbance or movement occurs perpendicular to the direction of travel of the wave.

One example from the following:

vibrating string, light, radio, S waves from an earhquake. **(2 marks)**

(ii) Longditudinal Wave



A longitudinal wave is one in which the disturbance occurs parallel to the line of travel of the wave. One example from the following: sound, P waves from an earthquake.

(2 marks)

b. A recent tsunami in had a wavelength of 750 km and travelled distance 3700 km in 5.3 h.

(i) What was the speed (in m/s) of the tsunami wave?

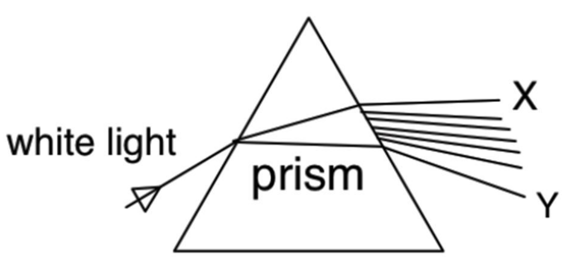
V = d/t
=3700/5.3
= 693 km/h
=693/3.6
=194 m/s ***(1 mark)***

(ii) Find the tsunami wave's frequency

$V = f\lambda$
$f = V/\lambda$
$=194/750\ 000$
$=2.59 \times 10^{-4}$ Hz ***(1 mark)***

Question 3: The Wave Nature of Light

a. The diagram below shows white light being dispersed by a prism.



What colour would be seen X?

Red ***(1 mark)***

b. The following 3 terms are properties of light and are evidence for either the particle or wave model. Place each term as evidence for the individual model or where appropriate as evidence for both models. USE EACH TERM ONCE ONLY.

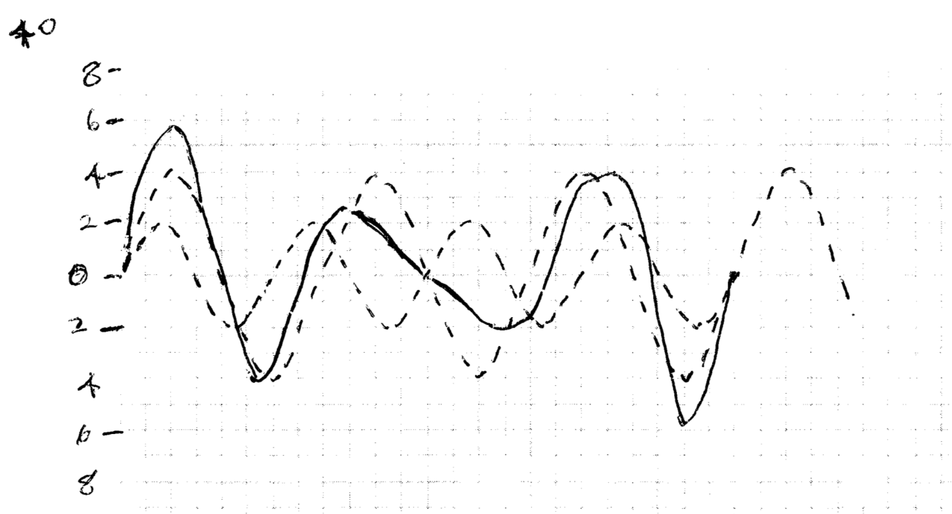
refraction, reflection, photoelectric effect

Particle Model only	Wave Model Only	Both models
Photoelectric effect	refraction	reflection

(3 marks)

Question 4: Diffraction and Interference of Light Waves

a. On the squared paper, draw two waves, one with an amplitude of 4cm and wavelength 8 cm and the other with amplitude 2cm and wavelength 6cm (start both waves from the origin). Superimpose the two waves to find the resultant wave. (Each square = 1cm)



(2 marks)

b.

(i) Describe the results Thomas Young would have observed in his Double Slit experiments in 1802 and 1804.

Results: A symmetrical fringe pattern of bright and dark fringes either side of a central bright fringe. ***(2 marks)***

(ii) In a Young's double-slit experiment, the wavelength of the light used is 520 nm (in a vacuum), and the separation between the slits is 1.4×10^{-6} m. Determine the angle that locates

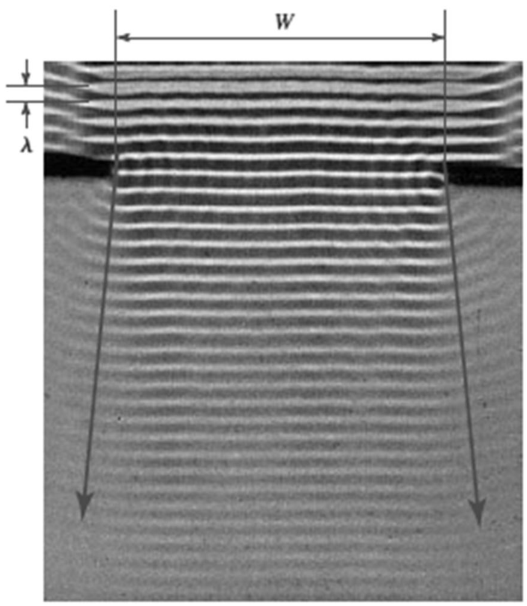
The bright fringe for which n = 1

$d\sin\Theta = n\lambda$

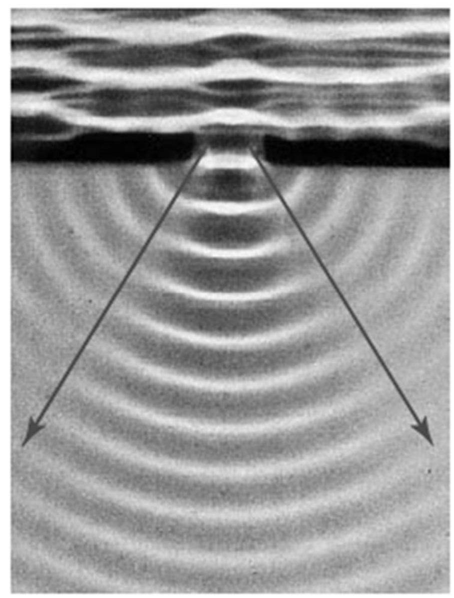
$\Theta = \sin^{-1}((1) \times 520 \times 10^{-9}/1.4 \times 10^{-6})$
$= 22^0$
(n – ½)ઋ= dsin Θ
$\Theta = \sin^{-1}(½\ 520 \times 10^{-9}/1.4 \times 10^{-6})$
$= 11^o$ ***(2 marks)***

c. Diagrams I and II show a series of waves generated in a wave tank. In both cases the waves are travelling down the page. Explain why different patterns are observed for I and II

I



II



In I, the ratio of wavelength/gap is small because the wavelength (as indicated by the distance between the wave fronts) is small relative to the width of the opening. The wave fronts move through the opening with little bending or diffraction into the regions around the edges.

In II, the wavelength is larger and the width of the opening is smaller. As a result, the ratio wavelength/gap is larger, and the wave fronts bend more into the regions around the edges of the opening. ***(2 marks)***

Question 5: Kinematics — the Description of Motion

a. Light travels at 3×10^8 m/s in a vacuum. How long does light take to reach the Earth from the Sun at a distance of 150,000,000 km?

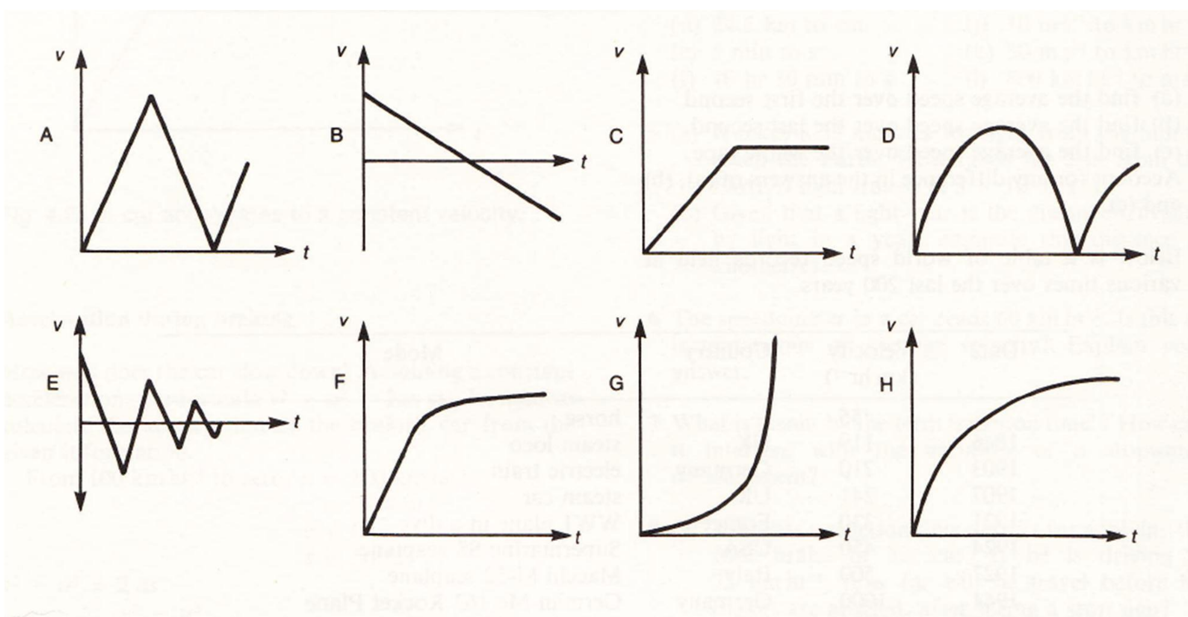
v = d/t
t = d/v

= 150,000,000,000(m)/ 3 x 10^8
= 500s or 8.3 minutes

(2 marks)

b. The following graphs represent graphs made by Physics students studying various motion events. Unfortunately they have been mislabelled. Indicate which velocity-time graph(s) represent the following situations by placing the letter from the graph(s) next to the statement:

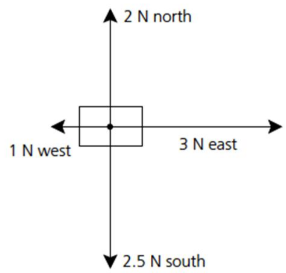
I. A ball thrown into the air.
B
II. A stone dropped from a great height.
H
III. A bouncing ball.
E
IV. A car accelerating uniformly to a constant velocity.
C,F
V. An object moving with an increasing acceleration
G



(5 marks)

Question 6: Vectors and Scalars

a. Calculate the resultant force acting on the object shown in the figure below.



***F**1 = **F**S + **F**N*
= 2.5 N south + (2.0 N north)
= 2.5 N south + (–2.0 N south)
= 0.5 N south
***F**2 = **F**E + **F**W*
= 3.0 N east + (–1.0 N east)
= 2.0 N east
***F**R = 0.5 N south + 2.0 N east (see Figure 4.4)*
= √0.52 + 2.02
= 2.1 N
ϑ = 14° so the direction is E14°S

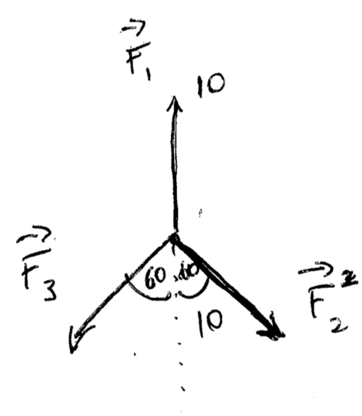
1 mark for resolving; *1 mark for Pythagoras* ***(2 marks)***

b. Three people pull simultaneously on a chair as represented by the following:

$\vec{F}_1$ = 10 N North
$\vec{F}_2$ = 10 N S60°E
$\vec{F}_3$ = 10 N S60°W

(i) Draw a diagram to represent the three forces.

61 a



(1 mark)

(ii) Find the resultant force on the chair.

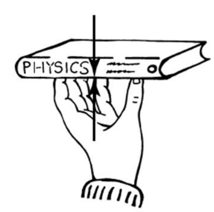
N/S direction
F_1 = 10N
F_2 = -10cos60
=-5N
F_3 = -10cos60
=-5N
Resolve in N/S direction
F_1 +F_2 + F_3
=10-5-5
=0N

Resolve E/W direction
F_1 = 0N
F_2 = 10sin60
=8.66N
F_3 = -10sin60
=-8.66N
F_{Total} = F_1 + F_2 + F_3
=0+8.66-8.66
=0N

Therefore by resolving N/S and E/W components the resultant force =0N
The chair is stationary. ***(1 mark)***

Question 7: Dynamics - The Causes of Motion

a. The diagram shows a physics book held at rest in a person's hand. Two forces are shown in the diagram. One is the weight of the book pushing down and the other is the force of the hand pushing up.



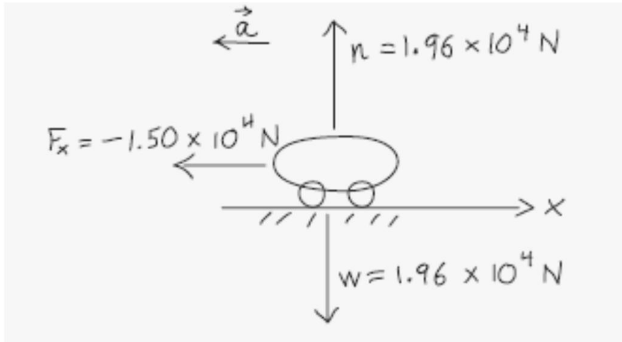
The hand is now suddenly removed. What would be observed? Explain your answer in terms of Newton's Laws of Motion.

When the hand is removed, the book is acted upon by gravity only, and according to Newton's Second Law the object will accelerate at 9.8 m/s^2

(1 mark)

b. A bus weighing 1.96 x 10^4N travelling in the direction x, makes a fast stop; the *x* component of the net force acting on the bus is -1.5 x 10^4N.

(i) Draw a diagram to show the forces acting on the bus.



1 mark for all components ***(1 mark)***

(ii) What is the bus' acceleration?

m_{bus}= w/g

= $1.96 \times 10^4/9.8$

= 2000kg

1 mark for correct calculation of the mass of the bus.

Newton's Second Law

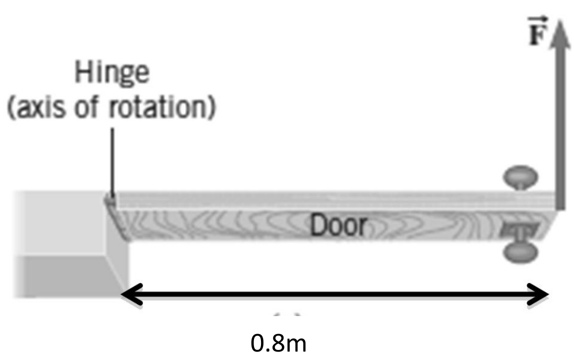
$F_x = ma_x$

$a_x = F_x/m$

= $-1.5 \times 10^4/2000$

= -7.5 m/s^2 ***(2 marks)***

c. The diagram shows a top view of a door. If a student applies a torque of 44 N.m to the handle located 0.8m from the hinge, calculate the force applied by the student.



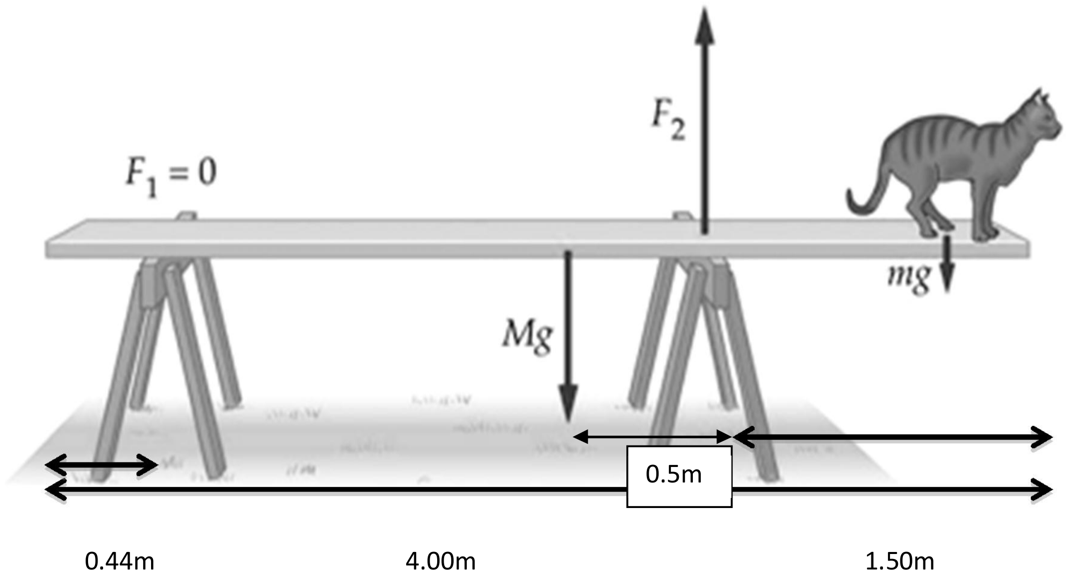
$\tau = F \times d$

$F = \tau/d$

= 44/0.8

= 55 N ***(2 marks)***

d. A cat walks along a uniform plank that is 4.00 m long and has a mass of 7.00 kg. The plank is supported by two sawhorses, one a 0.440 m from the left end of the plank and the other 1.50 m from the right end. When the cat reaches the right-hand end, the plank just begins to tip. What is the mass of the cat?



Centre of mass on plank is at the 2 m mark or .5m to the left of the right sawhorse

$\tau = F_1d_1 = F_2d_2$

$F_2 = F_1d_1/d_2$

$m_2g = m_1gd_1/d_2$

$m_2 = m_1d_1/d_2$

$= 7 \times 0.5/1.5$

$=2.33$kg **_(2 marks)_**

Question 8: Momentum

a. Define conservation of momentum.

The momentum before a collision (or explosion) is equal to the momentum after the collision (or explosion). **_(2 marks)_**

b. A car and driver of total mass 850 kg are travelling east along a straight road at a constant speed of 75.0 km h^{-1}. The car collides with a pole of mass 120 kg. The pole becomes wedged under the car within 0.350 s.

(i) Calculate the initial momentum of the car?

$p = mv$

$= 850 \times (75.0/3.6)$

$= 1.77 \times 10^4$ kg m s^{-1} east **(1 mark)**

(ii) After the collision, the car and pole move together as one system. What is the final momentum of the car–pole system? Explain your answer

1.77×10^4 kg m s^{-1} east.

Conservation of momentum **(1 mark)**

(iii) Calculate the speed of the car/bin after collision

$p = mv$

$v = p/m$

$=1.77 \times 10^4/9.7 \times 10^2$

$= 18.3$ m/s **(1 mark)**

(iv) Determine the magnitude of the average force exerted on the pole by the car.

$\Delta p_{pole} = m(v - u)$

$= 120(18.3 - 0)$

$= 2.19 \times 10^3$ kg m s^{-1} east

$F_{av} = \Delta p$

$= (2.19 \times 10^3)/0.35$

$= 6.26 \times 10^3$ N **(1 mark)**

Question 9: Acceleration in Gravitational Fields

a. A physics student stands on a bathroom scale that rests on the floor of an elevator. When the elevator is at rest, the scale reads 600 N.

(i) Determine the mass of the student at rest

$m = w/g$

$= 600/9.8$

$= 61.2$kg

or use $g = 10$m/s^2 **(2 marks)**

(ii) Then the elevator begins to move upward with a constant acceleration of a = 2.00m/s^2. Determine the scale's reading while the elevator is accelerating upward.

When the system accelerates upward the weight is still 600N, but now the upward force the scale applies to the feet of the person is no longer in equilibrium. We use Newton's Second Law to relate the acceleration to the net force:

F – 600N = ma

F-600 = 61.2 x 2.00

F = 122 + 600

=722N

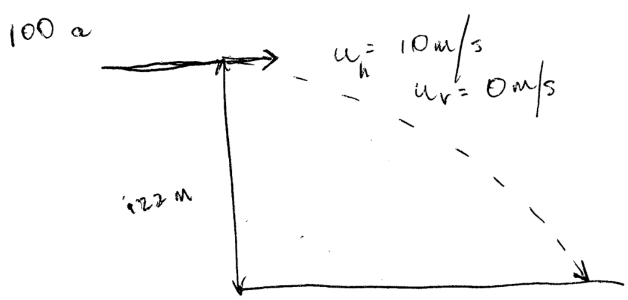
or use g = $10m/s^2$

1 mark for resultant; *1 mark for weight* ***(2 marks)***

Question 10: Kinematics in 2 Dimensions

a. A rock is thrown horizontally from a cliff 122 m high. Its initial velocity is 10m/s horizontally.

(i) Draw a diagram of the motion of the rock.



(2 marks)

(ii) Calculate the rock's displacement after 3s.

u = 10m/s horizontally

a = 9.8 m/s2 vertically

t = 3s

s = ?

v = ?

$s = ut + 1/2at^2$

using Pythagoras

$s^2 = s_{vertical}{}^2 + s_{horozontal}{}^2$ from $a^2 = b^2 + c^2$

$s^2 = (ut)^2 + (1/2at^2)^2$

$=(10 \times 3)^2 + (1/2 \times 9.8 \times 3^2)^2$

$s = \sqrt{(900 + 1945)}$

53.3m

$\tan\vartheta = 1/2at2/ut$

$=44.1/30$

$\vartheta = \tan^{-1} 44.1/30$

$=55.8^o$

$\therefore s = 55.3$ m at 55.8^o down from the horizontal

also accepted the distance dropped

$d = ut + ½ at^2$

$= 0 + (½ \times 10 \times 3^2)$

$= 45m$ **(2 marks)**

(iii) How long does it take the rock to reach the ground?

To calculate the time of flight, only the vertical component of the motion is considered. Here u = 0 and a = 9.8 m/s2 down and s = 122 m down.

$s = ut + 1/2at^2$

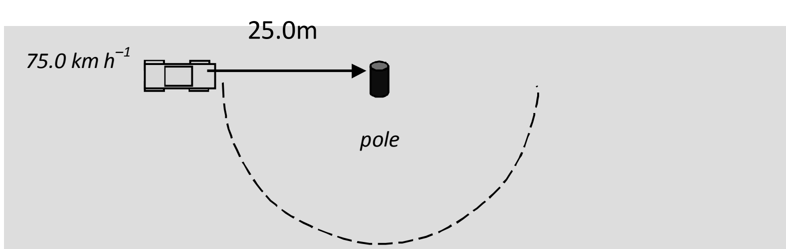
$122.5 = 0 + 1/2\ 9.8t^2$

$t^2= 122/4.9$

$t = 4.98\ s = 5s$ **(2 marks)**

Question 11: Circular Motion

a. The diagram below shows the course a truck travelling at 75.0 km/h must take to avoid a collision with a rubbish bin. The radius of the circular path is 25.0m.



(i) What is the magnitude of the acceleration of the truck taken on this path?

$v = (75.0/3.6)$

$= 23.83\ m\ s^{-1}$

$a = v^2/r$

$= 20.83^2/25$

$= 17.356$

$= 17.4\ m\ s^{-2}$ ***(1 mark)***

(ii) Explain how the driver can experience acceleration without any simultaneous change in speed.

Acceleration is a vector quantity: it has an associated direction and magnitude. Although the magnitude of the change in velocity does not alter, its direction alters. Therefore acceleration has occurred. ***(1 mark)***

(iii) If each of the tyres on the car can exert a maximum frictional force of 3600 N on the road, determine whether the car's tyres can exert the force required by the swerve to ensure that the car stays on the circular path.

For the described path the required F_c is:

$F_c = ma$

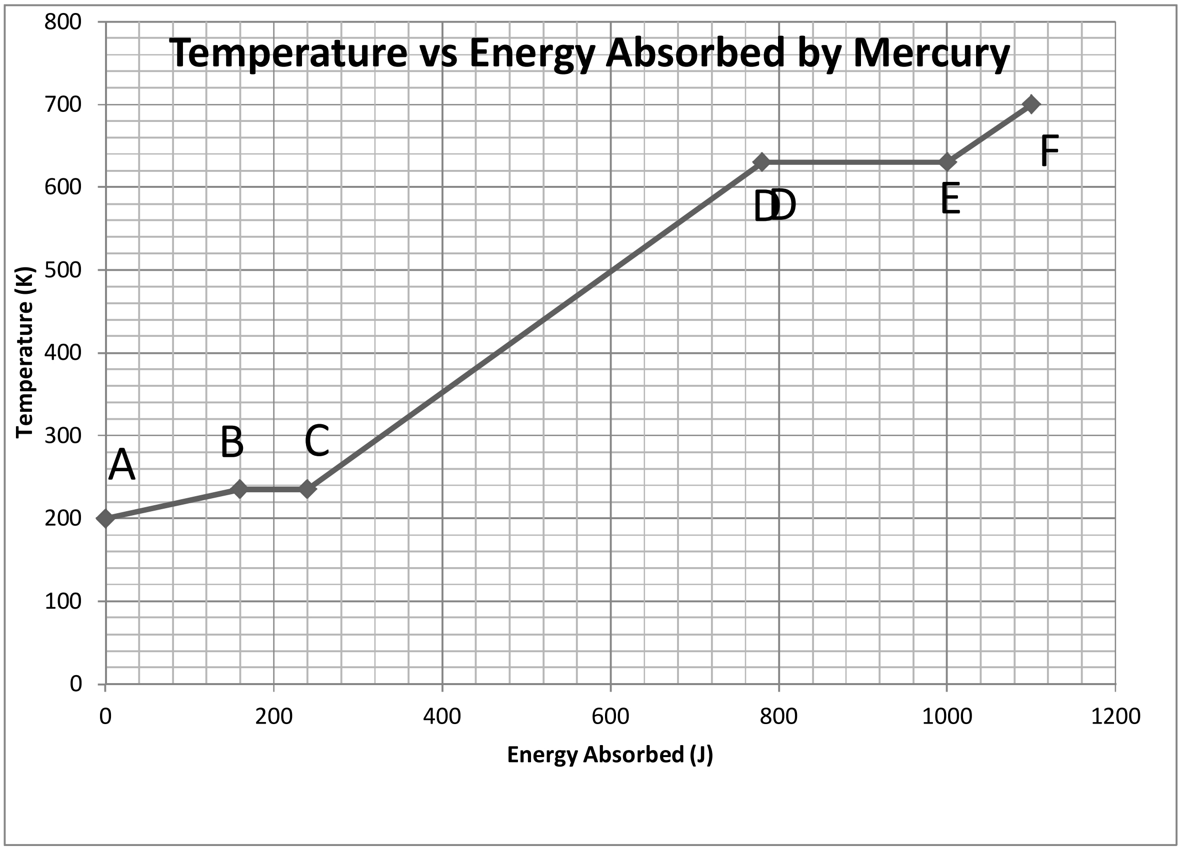
$= 850 \times 17.356$

$= 14\ 752\ N$

For each of the four tyres, 3688 N is therefore required. The maximum F_c of 3600 N is too small, so the car will not be able to follow the described path. ***(1 mark)***

Question 12: Work and Energy

a. The accompanying graph ABCDEF represents the change in internal energy (heat energy) — temperature relationship when energy is added to 1.0×10^{-2} kg of solid mercury at 200 K (under normal pressure) until all the mercury evaporates.



(i) Why is the temperature constant between DE as energy is added to the system?

Because the mercury is boiling at this temperature. Or change of state from liquid to gas

(1 mark)

(ii) From the graph, what is the approximate melting point of mercury?

230 $\pm$ 10 K ***(1 mark)***

(iii) What is the specific heat capacity of liquid mercury?

$H = mc\Delta T$

$c = H/m \times \Delta T$ ***(1 mark)***

$= (780 - 240)/ 1 \times 10^{-2} \times (630 - 230)$

$= 1.4 \times 10^{2}$ J/kg/K

b. You find that you have let a 12.0kg stainless steel BBQ plate becomes too hot for normal cooking. You decide to cool the plate from 296^{0}C to 185^{0}C by spraying water onto the plate.

Specific heat of steel, water and Latent heat of water are all given at front of test. Calculate the mass of water at 20^0C you will need. The boiling point of water is 100^0C

Use the following information as needed:

Latent heat of water	2256×10^3J/kg
Specific heat of water	4.19×10^3J/kg
Specific heat of iron (steel)	0.47×10^3 J/kg

$H_{steel} = mc\Delta T$

$=12 \times 0.47 \times 103 \times (296 - 185)$

$= 626040$ J

$H_{Water} = H_{Vapourisation} + H_{water}(100\text{-}20)$ *(1 mark)*

$=mL + (mc\Delta T)$

$=m(L + c\Delta T)$

Heat lost by steel = Heat gained by Water

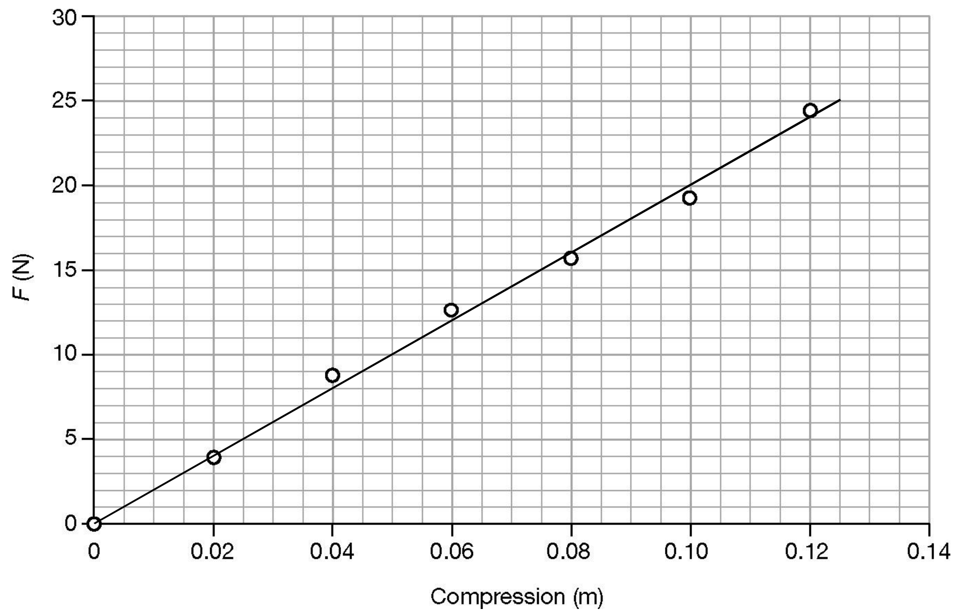
$626040 = m(L + c\Delta T)$

$m_{water} = 626040/((2256 \times 10^3) + 4.19 \times 10^3 \times (100\text{-}20))$

$= 0.23$kg

Therefore the mass of water needed to cool the BBQ is 230g or 230mL (1 mark) ***(2 marks)***

c. A spring-loaded pinball machine uses a spring in its firing mechanism. A group of students tested the spring and obtained the following data.



(i) Draw in the line of best fit for the data shown above and calculate its gradient and give an error range of 5%.

Slope =(25 – 4)/(.125 – 0.02)

=200 *Nm^{-1}*

Accuracy of line of best fit should allow a gradient of 200 $\pm$ 10 Nm^{-1}. ***(2 marks)***

Note the Question paper allocates 1 mark for this item.

(ii) What characteristic of the spring does the gradient of this line represent?

Stiffness or spring constant of the spring ***(1 mark)***

(iii) The spring is able to be compressed a maximum distance of 0.080 m when it is in the pinball machine. How much energy is stored in the spring at this compression?

W = Fs in this case we can calculate from the graph

Area = ½ × base × height

= ½ × 0.08 × 16

= 0.64 J ***(2 marks)***

(iv) The spring is used to launch a metal ball of mass 60.0g. If the spring is compressed to 8.0 cm and 90% of the elastic potential energy is transferred to the ball. Calculate the launch speed of the ball.

$0.9\ U_e = E_k$

Area under graph = ½ mv^2

$0.9 \times 0.64 = ½ \times 0.060 \times v^2$ (1 mark)

$= \sqrt{[(2 \times 0.576)/0.06]}$

$= \sqrt{19.2}$

$v = 4.4\ m\ s^{-1}$ **(2 marks)**

d. A box of mass 0.10kg is resting on the ground. A force of 2.0N is applied to the box vertically upward and accelerates the box upward.

(i) When the box has risen a distance of 10m, what work has been done by the 2.0N force?

W = Fs

= 2.0 x 10

= 20J **(1 mark)**

(ii) What is the change in gravitational potential energy?

mgh = 0.1 x 9.8 x 10

= 9.8J

or use g = $10m/s^2$ **(1 mark)**

(iii) Assuming that the body accelerates when the 2.0N force is applied, calculate the velocity of the body at 10m.

Fs = mgh + KE

20 = 9.8. + KE

∴KE gained = 10.2J

KE = $1/2mv^2$

$v^2 = 2KE/m$

= 2 x 10.2/0.1

v = 14m/s **(1 mark)**

Question 13: Ideal Gas Law and Kinetic Theory

a. A sample of gas has an initial volume of 2L volume and a pressure of 760 mm of Mercury. If the gas is in an elclosed system and the temperature is held constant, find the final volume when the pressure changes to 40mm of Mercury.

$P_1V_1 = P_2V_2$ (1 mark)

$V_2 = P_1V_1/ P_2$

=760 x 2/40

= 38L (1 mark) ***(2 marks)***

b. A piston fits neatly into a syringe containing 1L of gas at 15°C. The pressure of the piston remains constant and the temperature is raised to 95°C

(i) Convert the initial temperature to Kelvin.

T_1 = 15°C = 15+ 273 = 288K ***(1 mark)***

(ii) Calculate the final volume of the piston.

V_1 = 1L

T_1 = 15°C = 15+ 273 = 288K

T_2 = 95°C = 95 + 293 = 368K

V_2 = ?

$\frac{\square\square}{\square\square}=\frac{\square\square}{\square\square}$ *(1 mark)*

$V_2 = V_2T_2/VT_1$

=1 x 368/288

= 1.3L (1 mark) *(2 marks)*

c. How many moles of an ideal gas are present in a sample of 0.1 m^3 of a gas if the pressure of the gas is 380mm of Mercury and its temperature is 27°C?

T = (t + 273)K

= 27 + 273

= 300K (1 mark for temperature conversion)

From the equation of state

$PV = nRT$

$n = PV/RT$(1 mark)

$= 0.5$ atm $= 0.5 \times 101$ kPa $= 5.05 \times 10^4$ Pa (1 mark for pressure conversion)

$V = 0.1m^3$

$\therefore n = 5.05 \times 10^4 \times 0.1/8.31 \times 300$

$= 2.03$ moles (1 mark for n) **(3 marks)**

Question 14: Simple DC Electrical Circuits and Energy Transfer

a. Explain the difference between a conductor and an insulator.

A conductor has a low resistance because electrons flow easily under the influence of an electric field.

An insulator has a high resistance because charges inside the insulator do not move easily.

(2 marks)

b. A defibrillator is used during a heart attack to restore the heart to its normal beating pattern. A defibrillator passes 18 A of current through the body of a person in 2.0 m/s.

(i) How much charge moves during this time?

$I = Q/t$

$Q = It$

$= 18 \times 2 \times 10\text{-}^{3}$

$= 3.6 \times 10^{-2}$ C ***(1 mark)***

(ii) How many electrons pass through the wires connected to the patient?

$q = Ne$

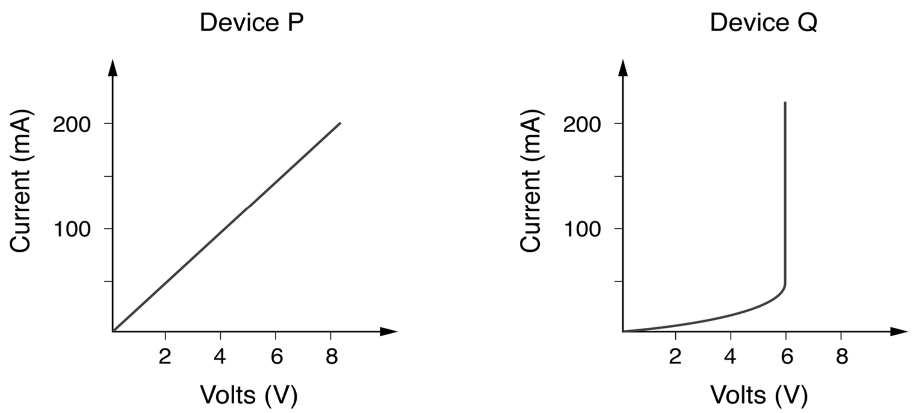
$N = q/e$

$=3.6 \times 10^{-2}/1.6 \times 10^{-19}$

$=2.25 \times 10^{17}$ electrons

The value given by students for (i) was used for this ***(1 mark)***

c. Two electrical devices (P and Q) have current–voltage characteristics as shown below.



(i) Which of the two Devices P or Q obeys Ohm's law? Explain your answer

The first one does, as the gradient is constant, the second does not. ***(1 mark)***

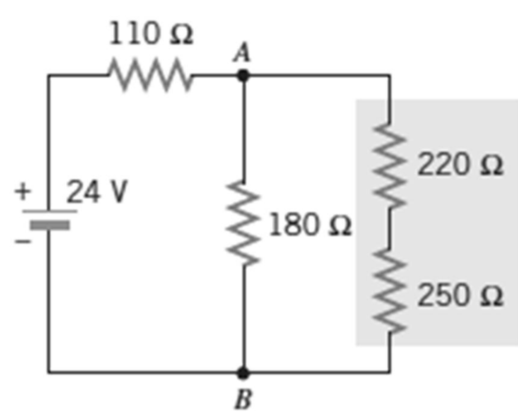
(ii) Determine the resistance of device P.

V = IR
R = V/I *(1 mark)*
From graph
=4/100x10^{-3}
=40Ω *(1 mark)* ***(2 marks)***

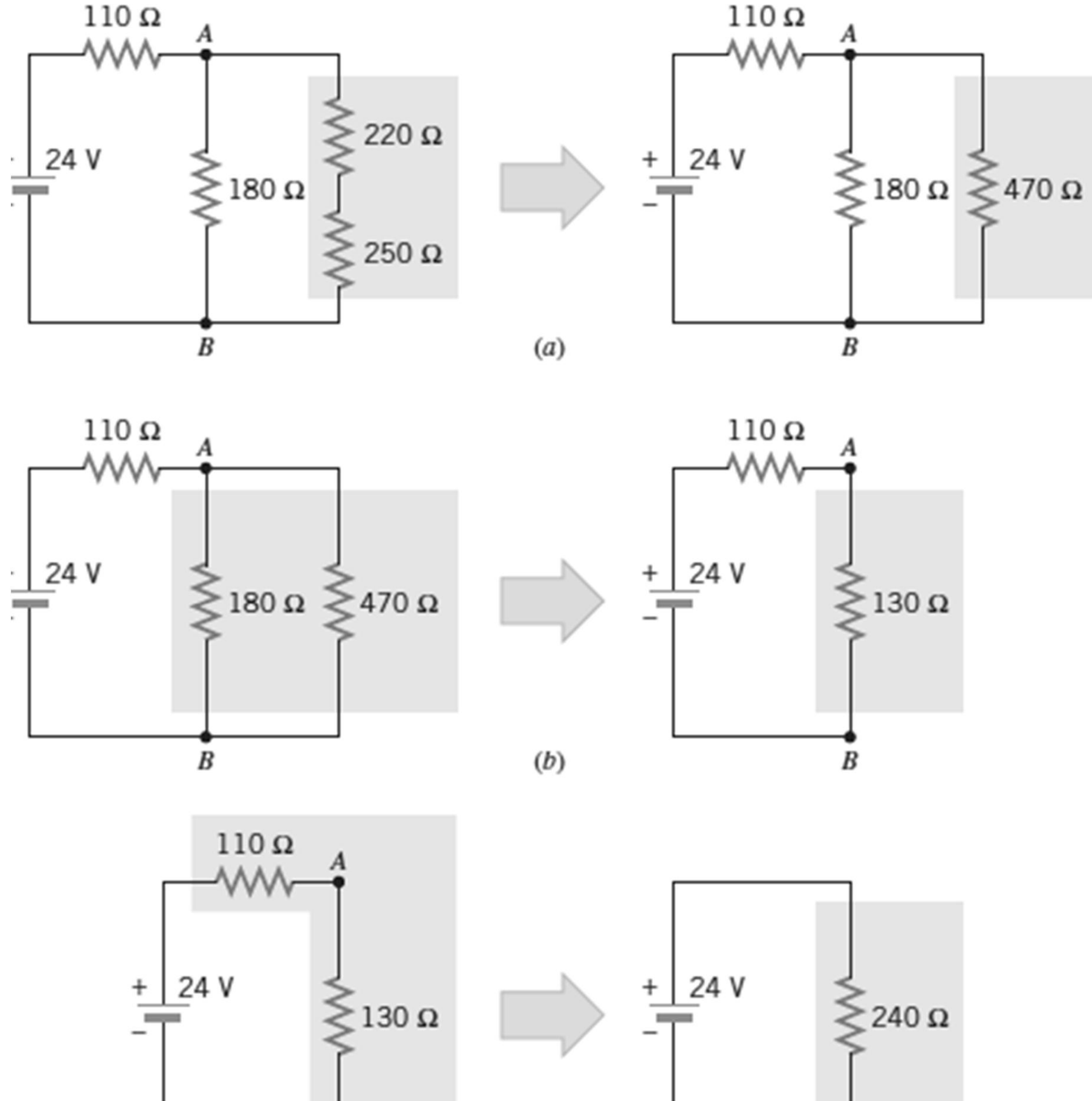
(iii) What is the resistance of device Q when a current of 200 mA flows through it?

V = IR
R = 6/200x10^{-3}
=30 Ω ***(1 mark)***

d. The figure below shows a circuit composed of a 24-V battery and four resistors, whose resistances are 110, 180, 220, and 250Ω respectively.



(i) Find the total current supplied by the battery



To find the total current we need to find the equivalent resistance of the circuit.

The 220Ω resistor and the 250Ω resistor are in series, so they are equivalent to a single resistor whose resistance is 220 + 250 = 470 Ω

The 470Ω resistor is in parallel with the 180Ω resistor. Their equivalent resistance can be obtained

$1/R_{AB} = 1/470 + 1/180$

$=0.077\Omega^{-1}$

So

$R_{AB} = 1/0.077$

$= 130\Omega$

The circuit is now equivalent to a circuit containing a 110Ω resistor in series with a 130Ω resistor.

This combination behaves like a single resistor whose resistance is

$R_{Total} = 110 + 130$

$= 240\Omega$ *(1 mark)*

The total current from the battery is

$I = V/R$

$= 24/240$

$=0.1A$ *(1 mark)* ***(2 marks)***

(ii) the voltage between points A and B in the circuit.

The current *I* = 0.10 A passes through the resistance between points *A* and *B*. Therefore, Ohm's law indicates that the voltage across the 130Ω resistor between points *A* and *B* is

$V = IR$

$= 0.1 \times 130$*(used value from (i)*

$=13V$ ***(2 marks)***

e. Two heating coils A and B are connected in parallel with a 240 V supply. A is rated at 1kW and B at 2kW.

(i) Calculate the resistances of A and B.

From $V = IR$ *and* $P = IV$

$P = V^2/R$

So $R_A = V^2/P$

$= 240^2/1000$

$=57.6\Omega$ *(1 mark)*

$R_B = V^2/P$

$=240^2/2000$

$=28.8\Omega$ *(1 mark)* ***(2 marks)***

(ii) If the two coils are now connected in series, determine the loss or gain in power.

When placed in series, total resistance is equal to

$R_{total} = 57.6 + 28.8$

$=86.4\Omega$

$\therefore I = V/R$

$=240/86.4$

$=2.78A$ *(1 mark)*

Now

$P = I^2R$

So

$P_A = 2.78^2 \times 57.6$

$=445W$

$P_B = 2.78^2 \times 28.8$

$=233W$

$\therefore P_{total} = 445 + 233\ W$

$= 668W$

$\therefore$ *the change in power =*

$P_{initial} - P_{final}$

$=1000 + 2000 - 668$

$=2332W$ *(1 mark)* ***(2 marks)***

f. A battery charger is connected to a dead battery and delivers a current of 6.0 A for 5.0 hours, keeping the voltage across the battery terminals at 12 V in the process. 2 marks

(i) Determine the total charge delivered to the battery.

$\Delta q = I\Delta T$

$=6 \times 5hrs \times (3600s/1h)$

=1.1 x10^5 C **(1 mark)**

(ii) 95% of the energy delivered from the charger helps charge battery. Calculate how much is wasted as a heat by-product.

Energy = Δq x V

= 1.1 x10^5 C x 12V (used value from (i))

=1.3 x 10^{6}J

Energy dissipated = .05 x 1.3 x 10^{6}J

=65000J or 65kJ **(1 mark)**

Question 15: Magnetic Forces and Magnetic Fields

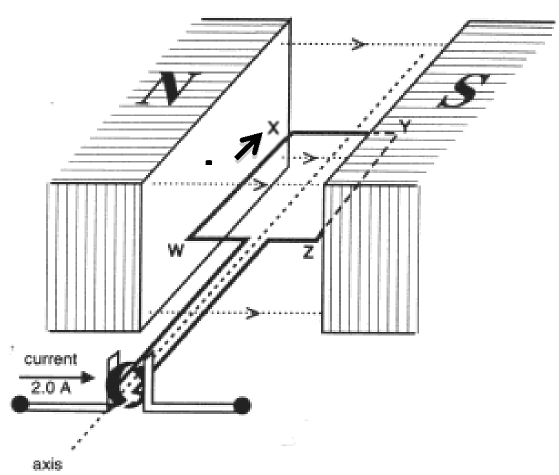
a. A high-tension wire carries a current of 120A directed from North to South. What is the direction of the magnetic field due to the current above the wire

Looking north along the wire, the current flows towards us, ie south
Using the right hand rule, the thumb of the right hand points out of the page. The fingers curl in the direction of the field.
So above the wire, the field is directed to the west.

(1 mark)

b. The coil of the motor was formed from 50 turns of wire. Each turn was rectangular, with sides WX and YZ 0.05m and XY and WZ 0.03m.

When a current of 2.0A is applied, the coil rotates between the poles of the magnet flowing from N to S with field strength 0.048 T.



(i) With an arrow, indicate the direction of movement of WX.

Force on WX is down, Force on YZ is up, so the direction is down. or anticlockwise

(1 mark)

(ii) What is the magnitude of the torque on the side YZ of the 50-turn coil when the coil is in the orientation shown in and the current in the coil is 2.0 A? 2 marks

τ = BANI (1 mark)
= 0.048 x 2 x 50 x (0.05 x 0.03)
=0.072Nm (1 mark) ***(2 marks)***

(iii) Describe two changes you would make and explain why each of these changes would increase the maximum torque on the coil.

Two of the following:

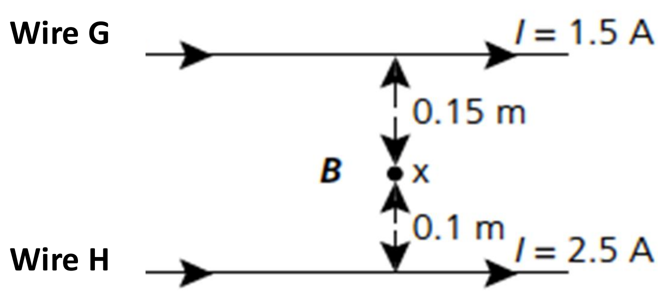
Stronger magnetic field will result in stronger force and ∴ torque.
Larger current will result in a larger force, etc.
More turns will results in a larger force, etc.
A longer length, WX and YZ will results in a larger force, etc.
A larger separation between WX and YZ will result in the forces being further apart, etc. ***(2 marks)***

(iv) In the motor, how is continuous rotation of the coil achieved?

Through the use of a commutator. ***(1 mark)***

Question 16: Magnetic Fields produced by Current Carrying Conductors

a. In the diagram below, two separate wires are close together. If wire G carries a current of 1.5A and wire H carries a current of 2.5A, calculate the value of the magnetic field strength at a point x between the two wires.



The magnetic field due to wire A at point x is:
B_G = kI/r
= 2 x 10^{-7} x1.5/.15
= 2 x 10^{-6} T into the page *(1 mark)*

The magnetic field due to wire B at point x is:
$B_H = kI/r$
$= 2 \times 10^{-7} \times 2.5/.1$
$= 5 \times 10^{-6}$ *T out of the page* *(1 mark)*

$B_{total} = B_G + B_H$ *(1 mark)*

Take the positive direction as out of the page
$\mathbf{B}tot= -(2 \times 10^{-6}) + (5 \times 10^{-6})$
$= 3 \times 10^{-6}$*T out of the pge* *(1 mark)* ***(4 marks)***

Question 17: Electromagnetic Induction

a. A jet aircraft with wing-span 30 m flies east to west, so that it is 90o to the lines of force of the Earth's magnetic field. The speed of the aircraft is 800 km/h, and the magnetic induction of the Earth's field is 5.0 x 10-5 T. Determine the magnitude of the e.m.f. induced between the tips of the wings of the aircraft.

$B = 5.0 \times 10^{-5}$ *T*

V = 800km/h = 222 m/s

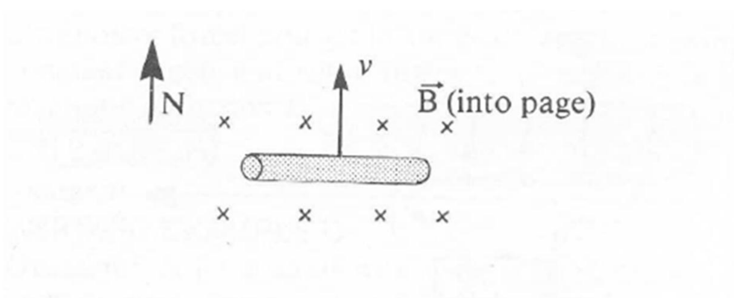
l = 30m

E = Bvl *(1 mark)*

= 5 x 10-5 x 222 x 30

= 0.33V *(1 mark)* ***(2 marks)***

b. Use Lenz's Law to determine the direction of the induced current in the straight rod below. Assume that the wire forms part of a circuit. The diagram



Answer:

The wire is moving North up the page, and Lenz's Law says that the force will oppose the change, so the force experienced by the wire is to the South of the page.

Use the right hand palm rule. The palm of the right hand points to the south of the page, the outstretched fingers point into the page, and the thumb points naturally in the direction of the current. This means that an induced current would flow to the west of the page.

(2 marks)

Question 18: Electrostatics

a. Two charged conducting spheres, suspended by insulating thread, are placed 10 cm apart. One has a charge of +2 μC and the other has a charge of +4 μC.

(i) Calculate the electrostatic force between the two conducting spheres

$F = kq_1q_2/d^2$

$= (9 \times 10^9 \times 2 \times 10^{-6} \times 4 \times 10^{-6})/.1^2$

$=7.2N$ ***(1 mark)***

(ii) The spheres are placed in contact with each other and then separated again to a distance of 10 cm. Calculate the new electrostatic force between them.

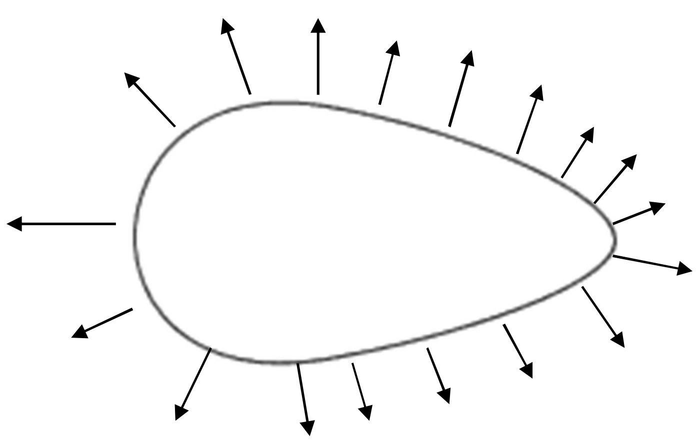
$\mathrm{F = kq_1q_2/d^2}$

$= (9 \times 10^9 \times 3 \times 10^{-6} \times 3 \times 10^{-6})/.1^2$

$=8.1\mathrm{N}$ ***(1 mark)***

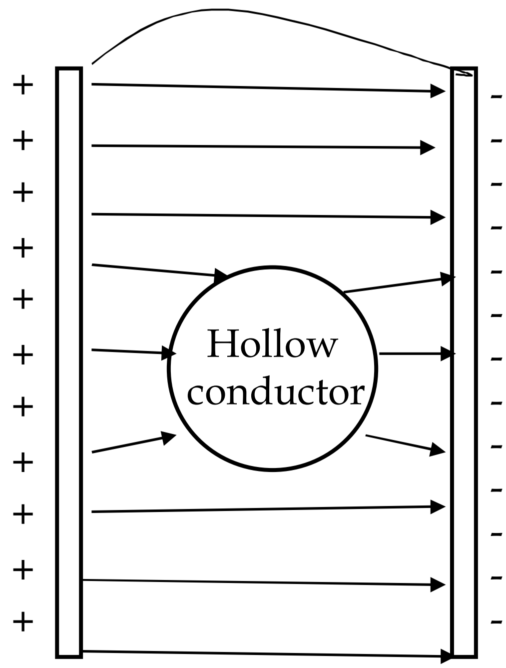
b. Draw the electric field pattern observed on the following:

(i) Around a pear shaped conductor that is charged positively.



(1 mark)

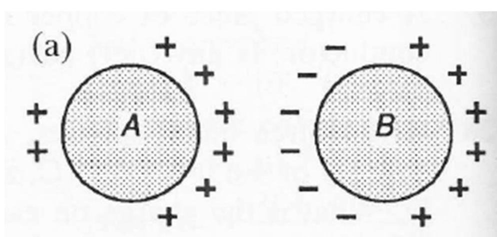
(ii) Two oppositely charged plates when a hollow conductor is placed between them.



(2 marks)

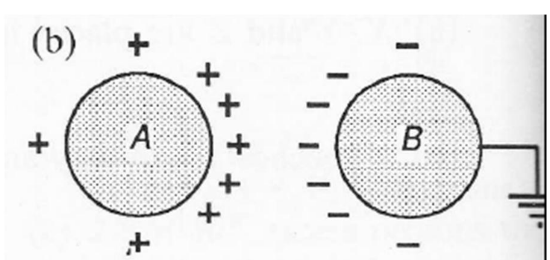
c. A positively charged metal sphere is isolated and the charge is distributed uniformly over its surface. An uncharged metal sphere of the same radius is brought close without contact.

(i) Sketch the distribution of charge on both spheres.



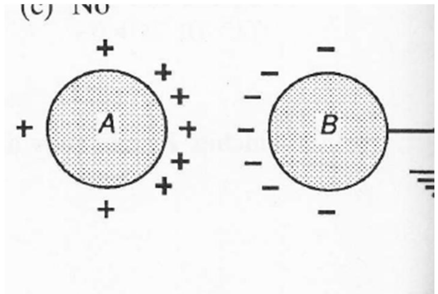
(2 marks)

(ii) The sphere B is earthed. Sketch the new distribution of charge.



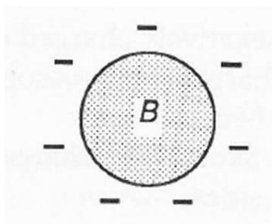
(1 mark)

(iii) The connection of the sphere B to earth is now broken, neither sphere being moved. Does the charge distribution change? Explain.



No the charge distribution on B is still the same ***(1 mark)***

(iv) Sphere A is now removed so that it no longer affects sphere B. Sketch the distribution of charge on B



(1 mark)

(v) Sphere B is now substituted with a perfect insulator, sphere C. Could it be charged through the same process? Explain.

Sphere C would have no net charge, the insulator does not have mobile charges, and ∴ cannot undergo charge by induction. ***(1 mark)***

Question 19: The Atom and Radioactivity

a. How does the Rutherford model of the atom describe the position of the positive and negative charge in an atom?

The positive charge of an atom resides in a massive positive core. (1 mark)

The negative electrons orbit the nucleus. (1 mark) ***(2 marks)***

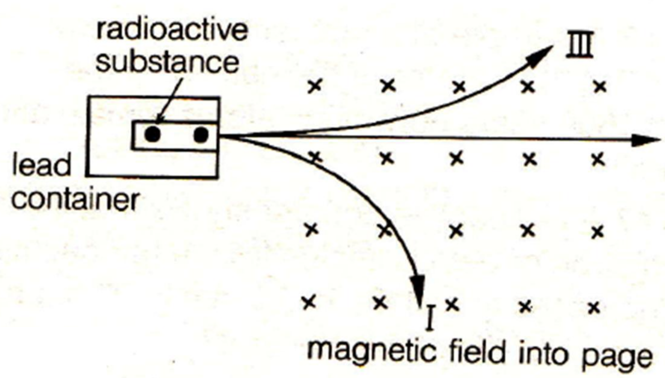
b. Explain the term isotope and use an example in your explanation.

An isotope has the same number of protons and electrons. (1 mark) *but differs in the number of neutrons. Thus it also differs in the mass number as well. (1 mark)*

Hydrogen has 1 proton but can have 0,1 or 2 neutrons to give a mass number of 1, 2 or 3 (1 mark)

(3 marks)

c. The diagram below shows what happens when radiation emitted by a radioactive substance is passed through a cloud chamber equipped with a magnet. I, II and III are the radiation types emitted by the radioactive source.



Complete the table by placing the correct numeral next to the radiation.

Radiation	Numeral
Alpha (α)	III
Beta (β)	I
Gamma (γ)	II

(3 marks)

Use the following table for question 193

Element	Symbol	Atomic Number
Uranium	U	92
Thorium	Th	90
Protactinium	Pa	91
Radium	Ra	88
Radon	Rn	86
Polonium	Po	84
Lead	Pb	82
Bismuth	Bi	83
Thallium	Tl	81

d. The radioisotope U_{235} undergoes alpha decay with a half-life of 710 million years.

(i) Explain what is meant by half-life of a radioisotope.

The half-life is the time that it takes for half the atoms of a particular substance to decay.

(1 mark)

(ii) Write an equation for the alpha decay of U_{235}

$U_{235} \rightarrow \frac{???}{??} Th + \frac{?}{?} He$ ***(1 mark)***

(iii) A sample of U_{235} contains 10^{15} atoms. How many atoms of U_{235} are left after 2.84×10^{9} years?

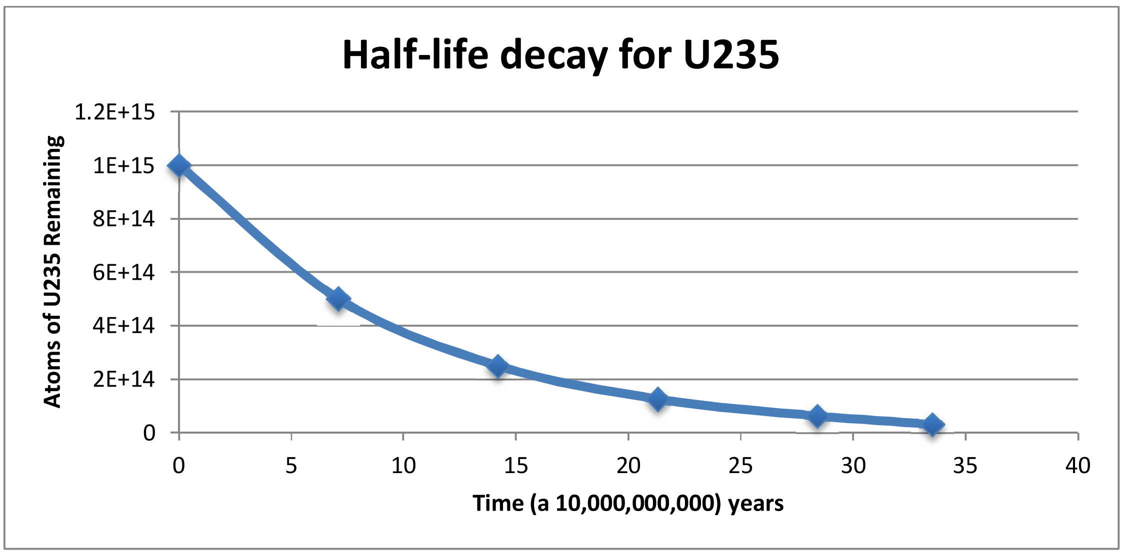
Number of half-lives = $2.84 \times 10^{9} / 7.1 \times 10^{8}$

= 4 half-lives

So the number of atoms of U_{235} = $10^{15}/16$

=6.25×10^{13} atoms ***(1 mark)***

(iv) Draw a graph of atoms left vs time for the time period 3.55×10^{9} years for U_{235}.



(3 marks)

SECTION B (20 Multiple choice questions worth 2 marks each) (40 Marks)

1. What does the term heat mean?

A. the internal energy of an object.
B. a measure of how hot an object is.
C. the absolute temperature of an object.
D. the molecular motion inside of an object.

ANS: A

2. Newton's theory of light treated light as ________ while Young demonstrated that light behaved as________ with ________ behavior. Which of the following completes this sentence?

A. particles, waves, refractive
B. particles, waves, interference
C. waves, particles, interference
D. waves, particles, refractive

ANS: B

3. When light of one wavelength from air hits a smooth piece of glass at an angle, all of the following will occur except?

A. reflection
B. refraction
C. dispersion
D. interference

ANS: C

4. When a highly coherent beam of light is directed against a very fine wire, the shadow formed has several parallel wires. This is explained by:

A. refraction
B. diffraction
C. reflection
D. dispersion

ANS: B

5. Yellow light is used in Young's double-slit experiment. Which of the following changes would cause the interference pattern to be more closely spaced?

A. Use slits that are closer together
B. Use a light source of higher intensity
C. Use a blue filter instead of a yellow filter
D. Move the light source further away from the slits.

ANS: C

6. Displacement can be found by taking the:

A. slope of an acceleration-time graph
B. area under an acceleration-time graph
C. slope of a velocity-time graph
D. area under a velocity-time graph

ANS: D

7. In the case of constant acceleration, the average velocity equals the instantaneous velocity:

A. at the beginning of the time interval.
B. at the end of the time interval.
C. half-way through the time interval.
D. three-fourths of the way through the time interval.

ANS: A

8. A student walks 10m due east, then 20m due north, then 5m due south. The magnitude of her displacement from her original position is closest to:

A. 35m
B. 18m
C. 5m
D. 25m

ANS: B

9. A car is moving along a road with a constant velocity. It can be concluded that:

A. Air resistance is not acting on the car
B. The resultant force on the car is zero
C. The resultant force acting on the car is equal to *mg*
D. The air resistance acting on the car is less than the weight of the car

ANS: B

10. Two cars collide at an intersection on a slippery road and stick together. It is true that:

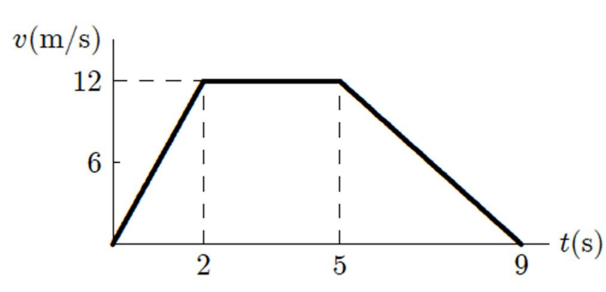
A. Momentum is conserved and kinetic energy is not
B. Momentum and kinetic energy are both conserved
C. Momentum is not conserved and kinetic energy is conserved
D. Neither momentum nor kinetic energy is conserved

ANS: A

11. A 8000-N car is traveling at 12m/s along a horizontal road when the brakes are applied. The car skids to a stop in 4.0 s. How much kinetic energy does the car lose in this time?

A. 4.8×10^4 J
B. 5.9×10^4 J
C. 1.2×10^5 J
D. 5.8×10^5 J

ANS: B



12. The diagram represents the straight line motion of a

car. Which of the following statements is true?

A. The car accelerates, stops, and reverses
B. The car accelerates at 6 m/s^2 for the first 2 s
C. The car decelerates at 12 m/s^2 for the last 4 s
D. The car returns to its starting point when t = 9 s

ANS: B

13. A particle moves at constant speed in a circular path. The instantaneous velocity and instantaneous acceleration vectors are:

A. both tangent to the circular path
B. both perpendicular to the circular path
C. perpendicular to each other
D. opposite to each other

ANS: C

14. A planet with the same mass, has a radius 3 times the radius that of Earth. What is the gravitational acceleration at the surface of the planet? (g= 9.8 m/s^2)

A. 29.4 m/s^2
B. 88.2 m/s^2
C. 1.08 m/s^2
D. 3.27 m/s^2

ANS: A

15. What is the temperature of a gas is most closely related to?

A. The average kinetic energy of translation of its molecules
B. Its total molecular kinetic energy
C. The sizes of its molecules
D. The total energy of its molecules

ANS: A

16. Both the pressure and volume of an ideal gas of diatomic molecules are doubled. What is the ratio of the new internal energy to the old, both measured relative to the internal energy at 0K, is

A. 1/4
B. 1/2
C. 2
D. 4

ANS: D

17. A conductor is distinguished from an insulator with the same number of atoms by the number of:

A. nearly free atoms
B. electrons
C. nearly free electrons
D. protons

ANS: C

18. A 2.0-m wire segment carrying a current of 0.60 A oriented parallel to a uniform magnetic field of 0.50 T experiences a force of what magnitude?

A. 6.7 N
B. 0.30 N
C. 0.15 N
D. 0 N

ANS: D

19. The formation of water from ice is accompanied by:

A. absorption of energy as heat
B. temperature increase
C. decrease in temperature
D. an evolution of heat

ANS: A

20. A step-down transformer is used to:

A. increase the power
B. decrease the power
C. increase the voltage
D. decrease the voltage

ANS: D