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Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

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1 (a) (i) $(50 \text{ to } 200) \times 10^{-3} \text{kg or } (0.05 \text{ to } 0.2) \text{kg}$  

B1 [1]

(ii) $(50 \text{ to } 300) \text{cm}^3$  

B1 [1]

(b) density $= \frac{\text{mass}}{\text{volume}}$ or $\rho = \frac{M}{V}$  

C1

$V = \pi (0.38 \times 10^{-3})^2 \times 25.0 \times 10^{-2} / 4 = (2.835 \times 10^{-8} \text{m}^3)$  

C1

$\rho = (0.225 \times 10^{-3}) / 2.835 \times 10^{-8} = 7940 \text{ (kg m}^{-3})$  

A1

$\Delta \rho / \rho = 2(0.01/0.38) + (0.1/25.0) + (0.001/0.225) = 0.061$  

or

$\% \rho = 5.3\% + 0.40\% + 0.44\% = 6.1\%$  

C1

$\Delta \rho = 0.061 \times 7940 = 480 \text{ (kg m}^{-3})$  

density $= (7.9 \pm 0.5) \times 10^3 \text{kg m}^{-3} \text{ or } (7900 \pm 500) \text{kg m}^{-3}$  


2 (a) (i) horizontal component $= 12 \cos 50^\circ = 7.7 \text{ m s}^{-1}$  

A1 [1]

(ii) vertical component $= 12 \sin 50^\circ \text{ or } 7.7 \tan 50^\circ = 9.2 \text{ m s}^{-1}$  

A1 [1]

(b) $v^2 = u^2 + 2as$ and $v = 0 \text{ or } mgh = \frac{1}{2}mv^2 \text{ or } s = \frac{v^2}{2} \sin^2 \theta / 2g$  

C1

$9.2^2 = 2 \times 9.81 \times h$ hence $h = 4.3 \text{ (4.31) m}$  

A1 [2]

alternative methods using time to maximum height of 0.94 s:

$s = ut + \frac{1}{2}at^2 \text{ and } t = 0.94 \text{ (s)}$  

(C1)

$s = 9.2 \times 0.94 - \frac{1}{2} \times 9.81 \times 0.94^2 \text{ hence } s = 4.3 \text{ m}$  

(A1)

or

$s = vt - \frac{1}{2}at^2 \text{ and } t = 0.94 \text{ (s)}$  

(C1)

$s = \frac{1}{2} \times 9.81 \times 0.94^2 \text{ hence } s = 4.3 \text{ m}$  

(A1)

or

$s = \frac{1}{2}(u + v)t \text{ and } t = 0.94 \text{ (s)}$  

(C1)

$s = \frac{1}{2} \times 9.2 \times 0.94 \text{ hence } s = 4.3 \text{ m}$  

(A1)

(c) $t \text{ (} = 9.2 / 9.81\text{)} = 0.94 \text{ (0.938) s}$  

C1

horizontal distance $= 0.938 \times 7.7 \text{ (} = 7.23 \text{ m)}$  

C1

displacement $= [4.3^2 + 7.23^2]^{1/2}$  

$= 8.4 \text{ m}$  

3  (a)  (i)  force \(= mg = 0.15 \times 9.81\) = 1.5 (1.47) N  

A1 [1]

(ii) resultant force (on ball) is zero so normal contact force = weight  
or  
the forces are in opposite directions so normal contact force = weight  
or  
normal contact force up = weight down  
A1 [1]

(b)  (i)  (resultant) force proportional/equal to rate of change of momentum  
B1 [1]

(ii) change in momentum = 0.15 \times (6.2 + 2.5) (= 1.305 N s)  
magnitude of force = 1.305/0.12  
= 11 (10.9) N  
A1

or  
(average) acceleration = (6.2 + 2.5) / 0.12 (= 72.5 m s\(^{-2}\))  
magnitude of force = 0.15 \times 72.5  
= 11 (10.9) N  
(A1)

(direction of force is) upwards/up  
B1 [3]

(iii) there is a change/gain in momentum of the floor  
M1

this is equal (and opposite) to the change/loss in momentum of the ball so momentum is conserved  
A1 [2]

or  
change of (total) momentum of ball and floor is zero  
(M1)  
so momentum is conserved  
(A1)

or  
(total) momentum of ball and floor before is equal to the (total) momentum of ball and floor after  
(M1)  
so momentum is conserved  
(A1)
4 (a) the energy (stored) in a body due to its extension/compression/deformation/ change in shape/size  

B1 [1]

(b) (i) two values of $F/x$ are calculated which are the same  
e.g. $10.4/40 = 0.26$ and $6.5/25 = 0.26$  

B1

or

ratio of two forces and the ratio of the corresponding two extensions are calculated which are the same  
e.g. $5.2/10.4 = 0.5$ and $20/40 = 0.5$  

(B1)

or

gradient of graph line calculated and coordinates of one point on the line used with straight line equation $y = mx + c$ to show $c = 0$  

(B1)

(so) force is proportional to extension (and so Hooke’s law obeyed)  

B1 [2]

(b) (ii) 1. $k = F/x$ or $k =$ gradient  

gradient or values from a single point used e.g. $k = 10.4/(40 \times 10^{-2})$  

C1

$k = 26 \text{ N m}^{-1}$  

A1 [2]

2. work done = area under graph  

or $\frac{1}{2}Fx$ or $\frac{1}{2}(F_2 + F_1)(x_2 - x_1)$  

or $\frac{1}{2}kx^2$ or $\frac{1}{2}k(x^2_2 - x^2_1)$  

C1

$= \frac{1}{2} \times 10.4 \times 0.4 - \frac{1}{2} \times 5.2 \times 0.2$  

or $\frac{1}{2} \times (5.2 + 10.4) \times 20 \times 10^{-2}$  

or $\frac{1}{2} \times 26 \times (0.4^2 - 0.2^2)$  

$= 1.6 \text{ J}$  

A1 [3]

(c) remove the force and the spring goes back to its original length  

B1 [1]

5 (a) $T = 4 \text{ (ms)}$ or $4 \times 10^{-3} \text{ (s)}$  

C1

$f = 1/T = 1/0.004$  

$= 250 \text{ Hz}$  

A1 [2]

(b) intensity $\propto$ (amplitude)$^2$ and amplitude = 2.8 (2.83) (cm)  

B1

curve with same period and with amplitude 2.8 cm  

B1

curve shifted 1.0 ms to left or to right of wave X  

B1 [3]
(c) (i) gradient = \((4.5 - 2.4) \times 10^{-3} / (3.25 - 1.75)\) \([= 1.4 \times 10^{-3}]\)  
\[\text{wavelength } = 0.45 \times 10^{-3} \times 1.4 \times 10^{-3}\]  
\[= 6.30 \times 10^{-7} \text{ (m)}\]  
\[= 630 \text{ nm}\]  
(ii) (gradient is equal to \(\lambda / a\) therefore) gradient of line is reduced  
value of \(x\) will be reduced for all values of \(D\)  
or new line is completely below old line  
or intercept is less

6 (a) (coulomb is) ampere second

(b) (total) charge or \(Q = nAe\)
\[I = Q/t \text{ and } l/t = v\]
\[I = nAe/t = nAe \text{ therefore } v = I/nAe\]

(c) (i) ratio = \(I/nAYii / I/nAz\)  
\[= A_2/A_Y \text{ or } 4A/A \text{ or } \pi d^2 / (\pi d^2 / 4)\]  
\[= 4\]  
(ii) \(R = \rho l/A\) or \(R = 4\rho l/\pi d^2\)
\[R_Y = \rho l/A \text{ and } R_Z = \rho (2l)/4A\]  
so \(R_Y/R_Z = 2\)  
or \(R_Y = 4\rho l/\pi d^2 \text{ and } R_Z = 4\rho l/\pi 4d^2 \text{ or } 2\rho l/\pi d^2\)  
so \(R_Y/R_Z = 2\)  
(iii) \(V = 12R_Y/(R_Y + R_Z) \text{ or } I = 12/(R_Y + R_Z) \text{ and } V = IR_Y\)
\[V = 12 \times 2/3\]
\[= 8.0 \text{V}\]  
(iv) ratio = \(I^2R_Y/I^2R_Z \text{ or } (V_Y^2/R_Y)/(V_Z^2/R_Z) \text{ or } (V_YI)/(V_ZI)\)
\[= 2\]
7  
(a) hadron: neutron/proton
    and
    lepton: electron/(electron) neutrino  B1 [1]  
    (allow other correct particles)

(b) (i) proton: up up down or uud  B1 [1]
    (ii) neutron: up down down or udd  B1 [1]

(c) (i) neutron $\rightarrow$ proton + electron + (electron) antineutrino  B1 [1]
    (ii) up down down (quarks) change to up up down (quarks)
        or
        down (quark) changes to up (quark)  B1 [1]