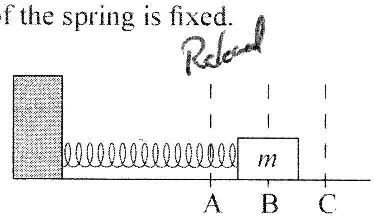
B2. This question is in **two** parts. **Part 1** is about simple harmonic motion and the superposition of waves. **Part 2** is about gravitational fields.

Part 1 Simple harmonic motion and the superposition of waves

An object of mass m is placed on a frictionless surface and attached to a light horizontal spring. The other end of the spring is fixed.



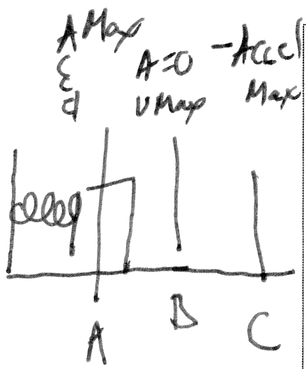
The equilibrium position is at B. The direction B to C is taken to be positive. The object is released from position A and executes simple harmonic motion between positions A and C.

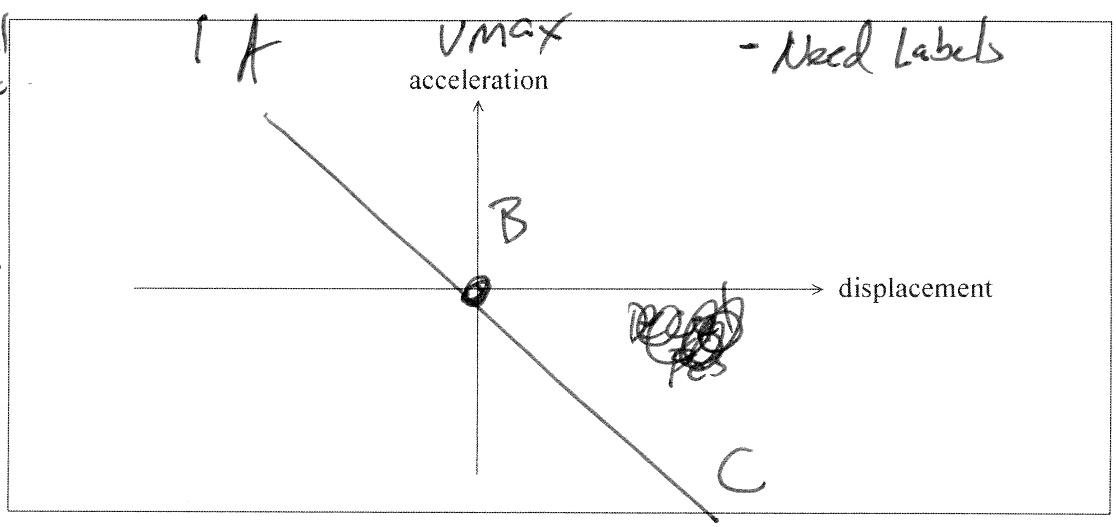
(a) Define *simple harmonic motion.* *[2]*

F = -Kx

- Force / Accel is proportional to the displacement From Equilibrium
- Force / Accel is directed toward the centre / Equilibrium Position

(b) (i) On the axes below, sketch a graph to show how the acceleration of the mass varies with displacement from the equilibrium position B. *[2]*





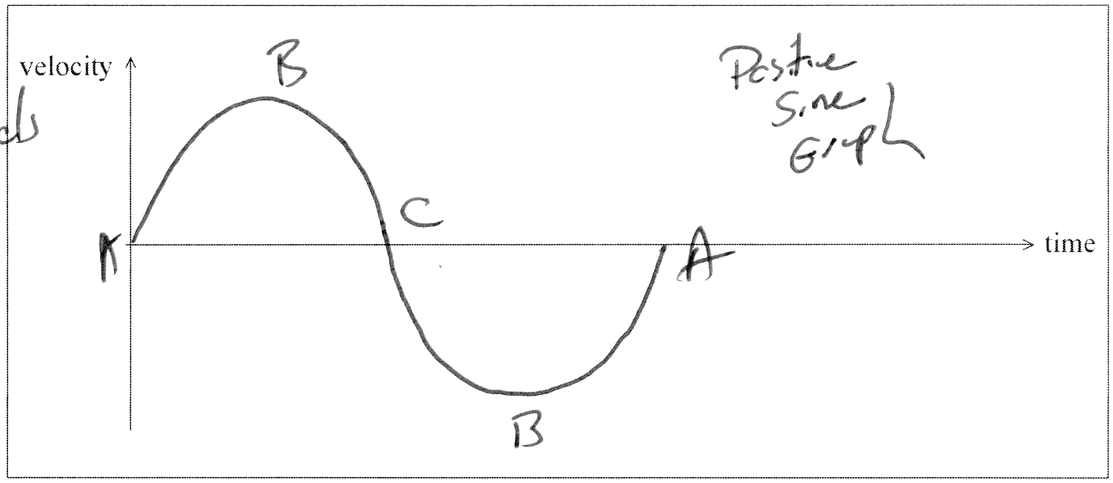
(ii) On your graph, label the points that correspond to the positions A, B and C. *[1]*

(This question continues on the following page)

(Question B2, part 1 continued)

(c) (i) On the axes below, sketch a graph to show how the velocity of the mass varies with time from the moment of release from A until the mass returns to A for the first time. *[2]*

- Need Labels



(ii) On your graph, label the points that correspond to the positions A, B and C. *[1]*

(d) The period of oscillation is 0.20 s and the distance from A to B is 0.040 m. Determine the maximum speed of the mass. *[3]*

x_0

$\omega = \frac{2\pi}{T} = \frac{2\pi}{0.20} = 31.42 \frac{rad}{sec} = 31 \frac{Rad}{sec}$

$V_{max} = \omega X_0$

$31 \frac{Rad}{sec} (0.040m) = 1.257 = 1.3$ m/s

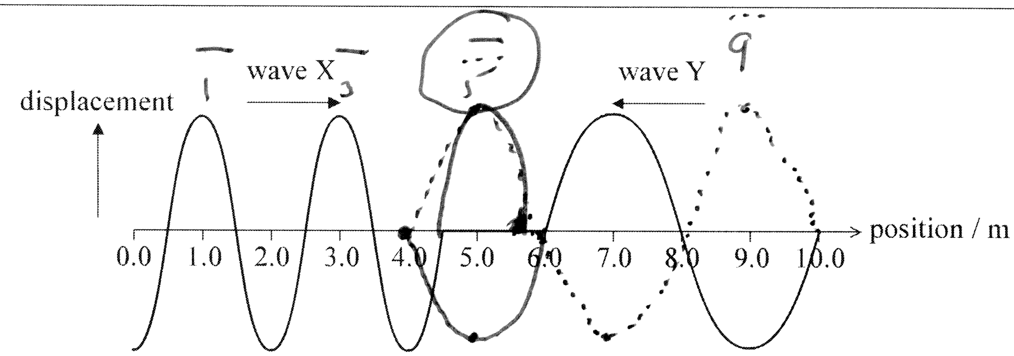
(This question continues on the following page)

(Question B2, part 1 continued)

(e) A long spring is stretched so that it has a length of 10.0 m. Both ends are made to oscillate with simple harmonic motion so that transverse waves of equal amplitude but different frequency are generated.

Wave X, travelling from left to right, has wavelength 2.0 m, and wave Y, travelling from right to left, has wavelength 4.0 m. Both waves move along the spring at speed $10.0\,m\,s^{-1}$.

The diagram below shows the waves at an instant in time.



(i) State the principle of superposition as applied to waves. *[2]*

If 2 or more waves pass through the same point, the resulting displacement is the sum of the displacements.

(ii) By drawing on the diagram or otherwise, calculate the position at which the resultant wave will have maximum displacement 0.20 s later. *[2]*

5m

(This question continues on the following page)

(Question B2 continued)

Part 2 Gravitational fields

(a) State Newton's universal law of gravitation. *[3]*

$F_g = \frac{G m_1 m_2}{r^2}$
- An Attractive Force.
- Exists between any two point masses.
- Force is inversley proportional to the distance between the two masses.

(b) Deduce that the gravitational field strength g at the surface of a spherical planet of uniform density is given by

~~DIAGRAM~~

$$g = \frac{GM}{R^2}$$

where M is the mass of the planet, R is its radius and G is the gravitational constant. You can assume that spherical objects of uniform density act as point masses. *[2]*

(This question continues on the following page)

$F_g = mg$

$F_g = \frac{G m M}{R_2}$

So $g = \frac{GM}{R^2}$

M - Mass of planet
m - mass of object on planet

(Question B2, part 2 continued)

(c) The gravitational field strength at the surface of Mars g_M is related to the gravitational field strength at the surface of the Earth g_E by

$$g_M = 0.38 \times g_E.$$

The radius of Mars R_M is related to the radius of the Earth R_E by

$$R_M = 0.53 \times R_E.$$

Determine the mass of Mars M_M in terms of the mass of the Earth M_E. [2]

Given $g = \frac{GM}{R^2}$

$g_M = \frac{M_M}{R^2_M}$ $= \frac{g_M}{g_E} = \frac{\frac{M_M}{R^2_M}}{\frac{M_E}{R^2_E}} = \frac{M_M}{M_E} = \frac{g_M}{g_E} \times \left[\frac{R_M}{R_E}\right]^2$

$g_E = \frac{M_E}{R_E^2}$

So

$M_M = .38 \times .53^2 M_E$

$M_M = .11 M_E$

(This question continues on the following page)

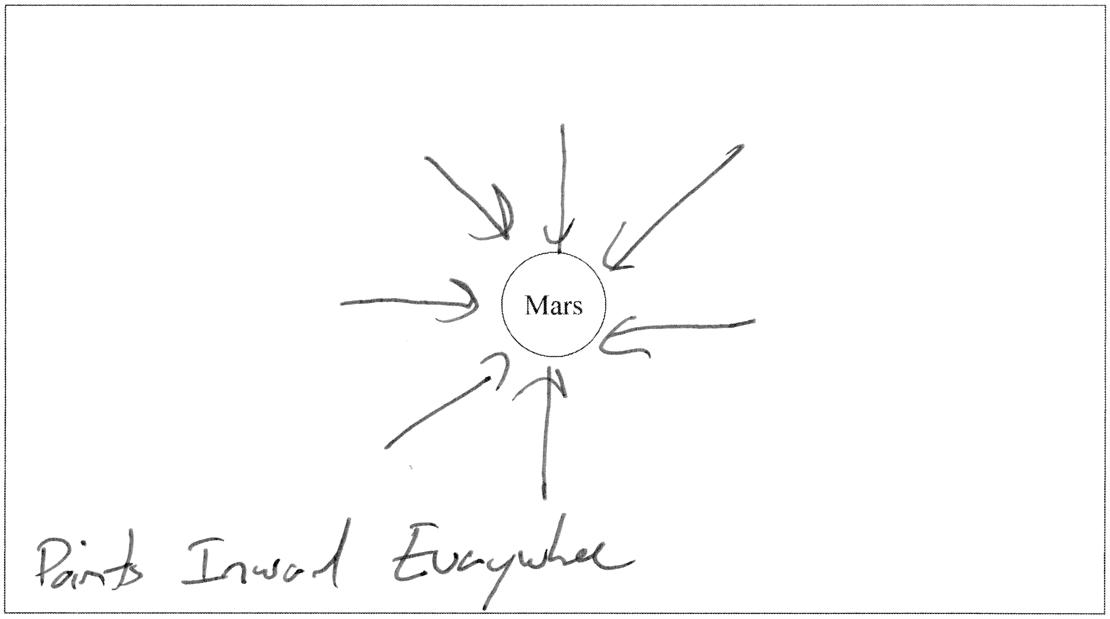
Refer to Eqn from (b)

If use a ratio, the G constant cancels out

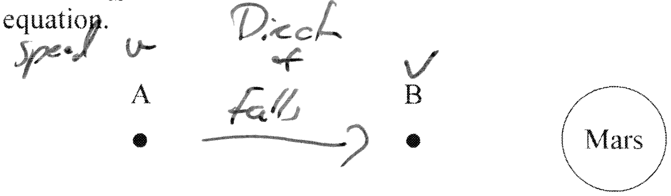
Keep Change Flip

(Question B2, part 2 continued)

(d) (i) On the diagram below, draw lines to represent the gravitational field around the planet Mars. *[1]*



(ii) An object falls freely in a straight line from point A to point B in time t. The speed of the object at A is u and the speed at B is v. A student suggests using the equation $v = u + g_M t$ to calculate v. Suggest **two** reasons why it is not appropriate to use this equation. *[2]*



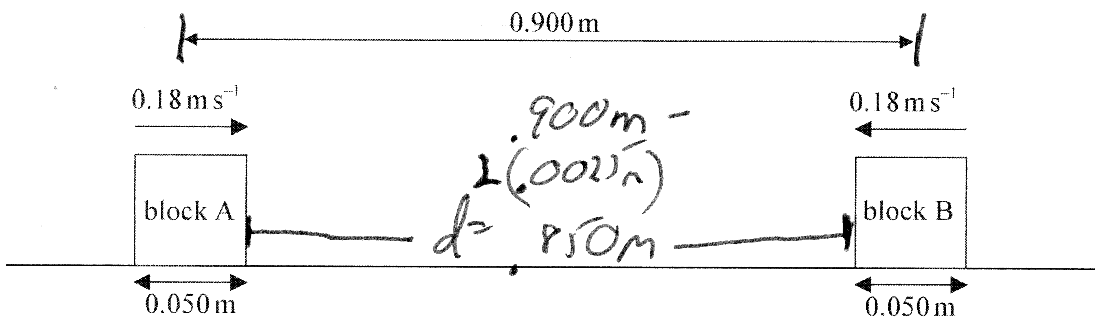
1: Accel is not constant between the 2 points

2: Field / Force between A & B is not equal to the Field / Force @ the surface

B3. This question is in **two** parts. **Part 1** is about a collision. **Part 2** is about electric current and resistance.

Part 1 A collision

Two identical blocks of mass 0.17 kg and length 0.050 m are travelling towards each other along a straight line through their centres as shown below. Assume that the surface is frictionless.



The initial distance between the centres of the blocks is 0.900 m and both blocks are moving at a speed of 0.18 m s^{-1} relative to the surface.

(a) Determine the time taken for the blocks to come into contact with each other. *[3]*

$\Delta v = V_A - V_B$

$.18 m/s - (-.18 m/s) = .36 m/s$

$d = .850 m$

$V = \frac{d}{t}$ $\quad .36 m/s = \frac{.850 m}{t}$ $\quad t = 2.4 s$

(This question continues on the following page)

(Question B3, part 1 continued)

(b) As a result of the collision, the blocks reverse their direction of motion and travel at the same speed as each other. During the collision, 20 % of the kinetic energy of the blocks is given off as thermal energy to the surroundings.

(i) State and explain whether the collision is elastic or inelastic. *[2]*

Inelastic - Momentum is conserved
Collision KE is not conserved

(ii) Show that the final speed of the blocks relative to the surface is $0.16\,\text{m}\,\text{s}^{-1}$. *[3]*

From Part 1

$KE_I = \frac{1}{2}mv^2 = \frac{1}{2}(.17kg)(.18m/s)^2 = .002754\,J$

$KE_f = .002754\,J \times .80 = .0022032\,J$

$2(KE_F) = 2\left(\frac{1}{2}mv^2\right)$

$\sqrt{\frac{2KE_F}{m}} = \sqrt{\frac{mv^2}{m}}$

$v = \sqrt{\frac{2(.0022032\,J)}{.17kg}}$

$v = .16\,m/s$

(This question continues on the following page)

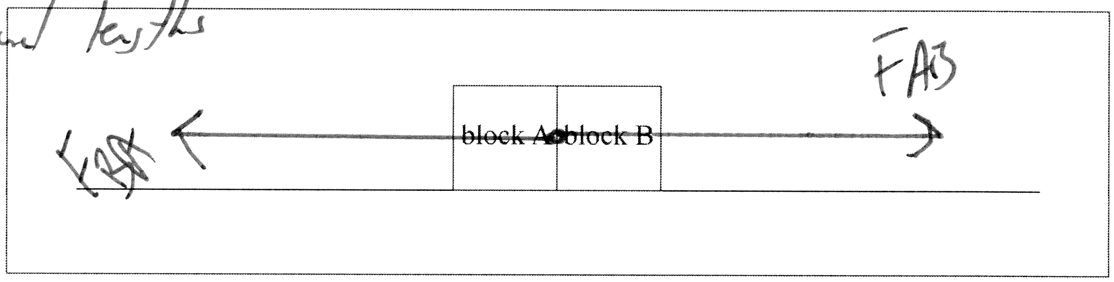
(Question B3, part 1 continued)

(c) (i) State Newton's third law of motion. Actn / Rxn *[1]*

If object A exerts a Force on object B, the B exerts and equal but opposite force on A simultaneously

(ii) During the collision of the blocks, the magnitude of the force that block A exerts on block B is F_{AB} and the magnitude of the force that block B exerts on block A is F_{BA}. On the diagram below, draw labelled arrows to represent the magnitude and direction of the forces F_{AB} and F_{BA}. *[3]*

- Forces are equal lengths
- Acts from the cent of mass
- Need label



(iii) The duration of the collision between the blocks is 0.070 s. Determine the average force one block exerted on the other. *[3]*

From Pg 22 $v_i = .18$ m/s
" Pg 23 $v_f = -.16$ m/s

$\Delta v = v_f - v_i$
$-.16$ m/s $- (.18$ m/s$)$
$= -.34$ m/s w/ speed
$= .34$ m/s no Dir

Impulse = Δ momentum
$Ft = m\Delta v$
$\frac{F(.070 s)}{.070 s} = \frac{.17 kg(.34 m/s)}{.070 s}$

$F = .83$ N

(This question continues on page 26)

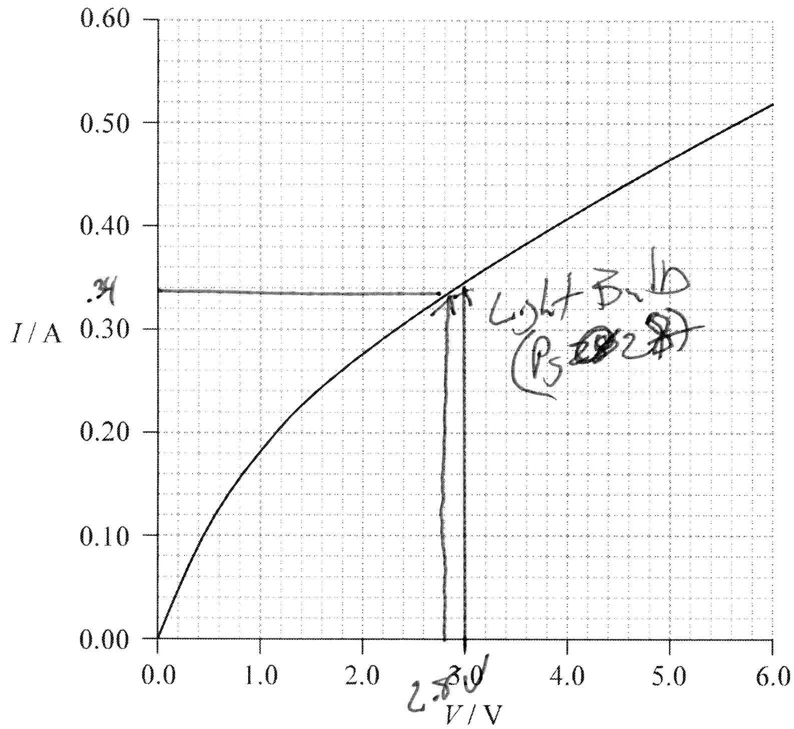
Please **do not** write on this page.

Answers written on this page
will not be marked.

(Question B3 continued from page 24)

Part 2 Electric current and resistance

The graph below shows how the current I in a tungsten filament lamp varies with potential difference V across the lamp.



(a) (i) Define the electrical *resistance* of a component. *[1]*

$R = \frac{V}{I}$ Ω = potential Difference across the Component / Current in the component

No Credit   Full Credit

(This question continues on the following page)

(Question B3, part 2 continued)

(ii) Explain whether or not the filament obeys Ohm's law. [2]

Ohm's law $R = \frac{V}{I}$ Voltage is proportional to the current

- Graph not linear, ohm's law not obeyed
- If you do two $R = \frac{V}{I}$ equations, R will be different

(b) (i) Calculate the resistance of the filament lamp when the potential difference across it is 2.8 V. [2]

From Graph 2.8V → .33A (Accept .32A – .34A)

$R = \frac{V}{I} = \frac{2.8V}{.33A} = 8.5\Omega$ (Accept 8.2Ω to 8.8Ω)

(ii) The length of the filament in a lamp is 0.40 m. The resistivity of tungsten when the potential difference across it is 2.8 V is $5.8 \times 10^{-7}\,\Omega\,\text{m}$. Calculate the radius of the filament. [3]

From b(i) R = 8.5Ω

$R = \frac{\rho L}{A} = \frac{5.8\times10^{-7}\,\Omega m\,(.4m)}{A} = 8.5\Omega$

$\frac{8.5A}{8.5} = \frac{2.32\times10^{-7}}{8.5}$

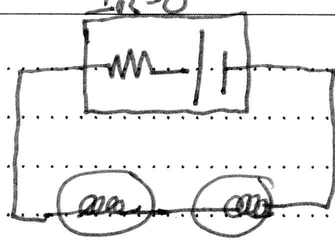
$A = 2.7\times10^{-8}\,m^2$ (Accept 9.2 – 9.5 × 10^-5 m^2)

(This question continues on the following page)

(Question B3, part 2 continued)

(c) Two identical filament lamps are connected in series with a cell of emf 6.0 V and negligible internal resistance. Using the graph on page 26, calculate the total power dissipated in the circuit. *[2]*

EMF = 6V
$I_R = 0$



Series
$V_T = V_1 + V_2$
$I_T = I_1 = I_2$
$R_T = R + R_2$

V = 3V, .34A   V = 3V, .34A

$V_T = V_1 + V_2$
$6V = V + V$
$6V = 2V$
$V = 3V$

From Graph 3V → .34A

$P = VI$
$3V(.34A) = 1.02W$ Each Bulb
×2
2.04W

Accept 2.0W to 2.1W

Only 1 pt. If use graph 6V → .52A P = 3.1W
Must go by components, Graph is not linear.