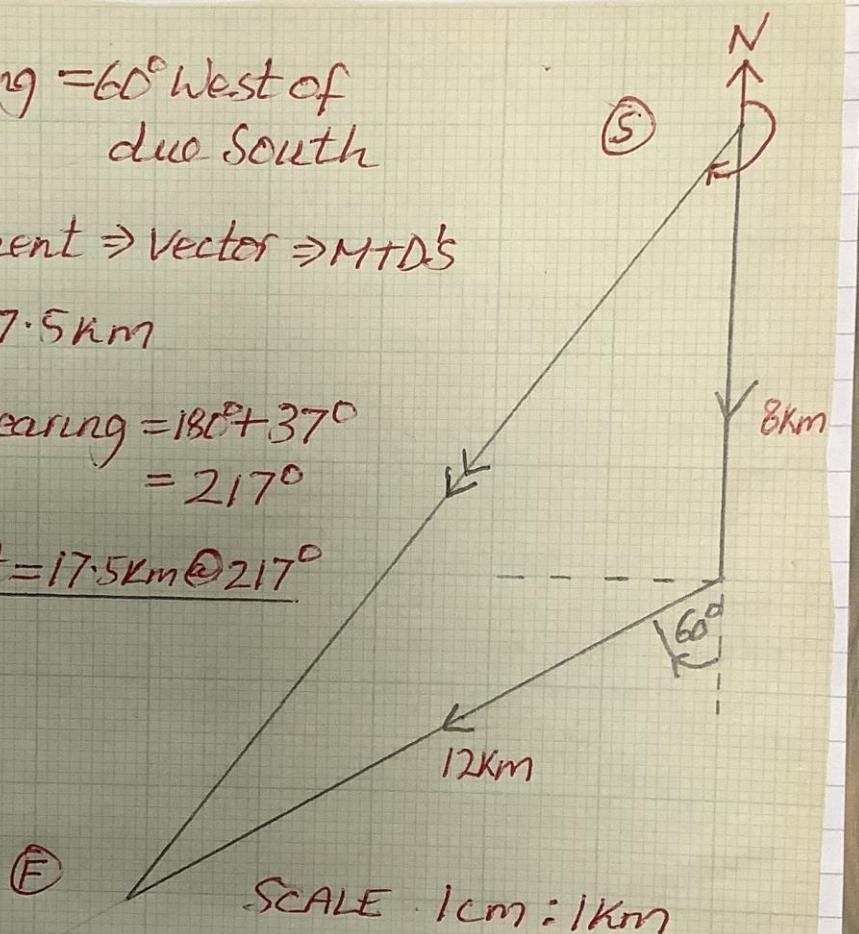


3. Our Dynamic Universe Revision Answers

1) a) Scale diagram (3)

- 240° bearing = 60° West of due South
- displacement \Rightarrow vector $\Rightarrow M + D's$
- $M \Rightarrow 17.5\text{ km}$
- $D \Rightarrow \text{Bearing} = 180^\circ + 37^\circ = 217^\circ$

$$\text{Displacement} = 17.5\text{ km} @ 217^\circ$$



SCALE 1cm : 1km

b) Average velocity = $\frac{\text{displacement}}{\text{time}} = \frac{17.5\text{ km} @ 217^\circ}{5\text{ h}} = 3.5\text{ km/h} @ 217^\circ$ (3)

c) Average speed = $\frac{\text{distance}}{\text{time}} = \frac{20\text{ km}}{5\text{ h}} = 4\text{ km/h}^{-1}$ (6)

Group 2 \Rightarrow time = $\frac{\text{distance}}{\text{Av. speed}} = \frac{17.5\text{ km}}{4\text{ km/h}^{-1}} = 4.38\text{ h}$

Group 2 total time = $4.38\text{ h} + 0.5\text{ h} = 4.88\text{ h}$
 Group 1 = 5h. \therefore Group 2 win by 0.12h. (4)

(2)

$$2) \text{ a) i) } v^2 = u^2 + 2as = 0^2 + 2 \times 9.8 \times 3.15 = 61.74$$

$$\Rightarrow v = \sqrt{61.74} = \underline{\underline{7.86 \text{ ms}^{-1}}} \quad (3)$$

$$\text{ii) } v^2 = u^2 + 2as = 0^2 + 2 \times 9.8 \times 1.75 = 34.3$$

$$\Rightarrow v = \sqrt{34.3} = \underline{\underline{5.86 \text{ ms}^{-1}}} \quad (2)$$

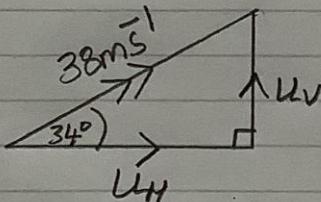
$$\text{b) i) mean} = \frac{\text{Total height}}{\text{Number}} = \frac{10.44}{6} = \underline{\underline{1.74 \text{ m}}}. \quad (1)$$

$$\text{ii) Random Uncertainty} = \frac{\text{max-min}}{\text{Number}} = \frac{(1.78 - 1.71)}{6} = \underline{\underline{0.01 \text{ m}}}$$

$$\frac{\text{Random Uncertainty}}{6} = \frac{0.07}{6} = \pm 0.01 \text{ m} = \underline{\underline{\pm 0.01 \text{ m}}} \quad (2)$$

$$\Rightarrow \text{Rebound heights} = \underline{\underline{(1.74 \pm 0.01) \text{ m}}}$$

3) a)



$$\bullet \sin 34^\circ = \frac{u_v}{38}$$

$$\Rightarrow u_v = 38 \sin 34^\circ = \underline{\underline{21.2 \text{ ms}^{-1}}}$$

• O to P

$$u_v = 21.2 \text{ ms}^{-1}$$

$$v_v = u_v + a_v t$$

$$v_v = 0$$

$$\Rightarrow 0 = 21.2 + (-9.8)t$$

$$a_v = -9.8 \text{ ms}^{-2}$$

$$\Rightarrow -21.2 = -9.8t$$

$$t = ?$$

$$\Rightarrow t = \frac{21.2}{9.8} = \underline{\underline{2.1 \text{ s}}}$$

(3)

• P to Q

$$U_V = 0 \text{ (max height)}$$

$$V_V = ?$$

$$a_V = -9.8 \text{ ms}^{-2}$$

$$S_V = -16.4 \text{ m}$$

$$t = ?$$

$$S_V = U_V t + \frac{1}{2} a_V t^2$$

$$\Rightarrow -16.4 = 0 + \frac{1}{2} \times -9.8 \times t^2$$

$$\Rightarrow -16.4 = -4.9 t^2$$

$$\Rightarrow t^2 = \frac{-16.4}{-4.9} = 3.35$$

$$\Rightarrow t = 1.83 \text{ s} \quad (5)$$

$$\text{Total time from O to Q} = 2.16 \text{ s} + 1.83 \text{ s} = \underline{4 \text{ s}}$$

b) • $\cos 34^\circ = \frac{U_H}{38} \Rightarrow U_H = 38 \cos 34^\circ$

$$\Rightarrow \underline{U_H = 31.5 \text{ ms}^{-1}}$$

• $S_H = U_H t + \frac{1}{2} a_H t^2$, $t = \text{total time}$
 $t = 4 \text{ s}$

$$\Rightarrow S_H = 31.5 \times 4 + 0$$

$$\Rightarrow \underline{S_H = 126 \text{ m}} \quad (4)$$

c) i) Horizontal distance would be (1)
 less than the 126m calculated.

ii) This is due to the force of friction
 in air acting against the ball.
 ie air resistance or drag force.

(1)

(4)

4) a) $R \uparrow = W \downarrow = mg = 66 \times 9.8 = \underline{647N} \quad (3)$

b) accelerating upwards $R \uparrow > W \downarrow$

$$\Rightarrow R = W + F$$

$$\Rightarrow R = 647 + 53$$

$$\Rightarrow R = \underline{700N}$$

$$F = ma = 66 \times 0.8$$

$$F = 52.8N$$

$$F = 53N \quad (3)$$

c) constant upwards velocity

$$\Rightarrow R \uparrow = W \downarrow = \underline{647N}. \quad (1)$$

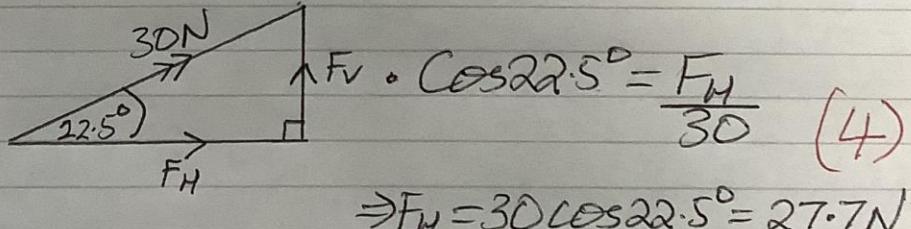
d) Negative acceleration upwards = deceleration upwards.

$$R \uparrow < W \downarrow \Rightarrow R = W - F$$

$$F = ma = 66 \times 0.6 = 39.6N \approx 40N$$

$$\Rightarrow R = W - F = 647 - 40 = \underline{607N} \quad (3)$$

5) a)



$$F_{HT} = 2 \times 27.7 = \underline{55.4N \text{ to the right}}$$

(5)

5) b) $a = F/m = \frac{55.4 - 4.4}{0.1} = \frac{51}{0.1} = 510 \text{ ms}^{-2}$ (3)

c) The acceleration does not remain constant as the stretch of the elastic chord decreases as the steel ball moves forward and so the unbalanced force decreases. (1)

6 a) Total momentum before collision =
Total momentum after the collision
(providing no external forces are acting) (1)

b) $\begin{array}{c} \textcircled{A} 1400 \text{ kg} \\ u_1 = ? \end{array} + \begin{array}{c} \textcircled{B} 1200 \text{ kg} \\ u_2 = 8 \text{ ms}^{-1} \end{array} = \begin{array}{c} 1400 \text{ kg} \quad 1200 \text{ kg} \\ \hline v_1 = v_2 = 15 \text{ ms}^{-1} \end{array}$

$$\begin{aligned} m_1 u_1 + m_2 u_2 &= m_1 v_1 + m_2 v_2 \\ \Rightarrow 1400 u_1 + 1200 \times 8 &= 1400 \times 15 + 1200 \times 15 \\ \Rightarrow 1400 u_1 - 9600 &= 21,000 + 18,000 = 39,000 \\ \Rightarrow 1400 u_1 &= 39,000 + 9,600 = 48,600 \quad (3) \\ \Rightarrow u_1 &= \frac{48,600}{1400} = 34.7 \text{ ms}^{-1} \text{ to the right.} \end{aligned}$$

c) $E_{KB} = \frac{1}{2} m_1 u_1^2 + \frac{1}{2} m_2 u_2^2 = \frac{1}{2} \times 1400 \times 34.7^2 + \frac{1}{2} \times 1200 \times 8^2 = 8.43 \times 10^5 + 3.84 \times 10^4 = 8.81 \times 10^5 \text{ J} \quad (3)$

$E_{KA} = \frac{1}{2} m_1 v_1^2 + \frac{1}{2} m_2 v_2^2 = \frac{1}{2} \times 1400 \times 15^2 + \frac{1}{2} \times 1200 \times 15^2 = 157,500 + 135,000 = 2.93 \times 10^5 \text{ J}$

$E_{KB} > E_{KA} \Rightarrow E_k \text{ is lost} \Rightarrow \text{INELASTIC COLLISION}$

(6)

Impulse = change in momentum.

7) a) $Ft = mv - mu$

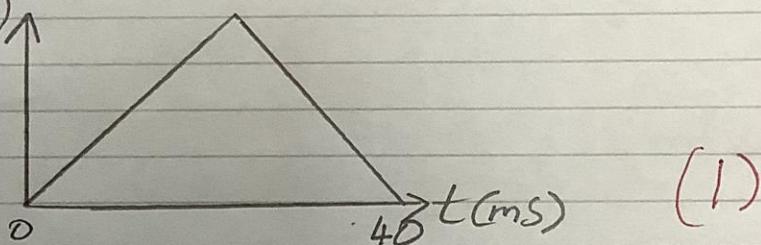
$$\Rightarrow F \times 40 \times 10^{-3} = (0.45 \times -8) - (0.45 \times 6)$$

$$\Rightarrow F \times 40 \times 10^{-3} = -3.6 - 2.7 = -6.3$$

$$\Rightarrow F = \frac{-6.3}{40 \times 10^{-3}} = -157.5 \text{ N} \approx -158 \text{ N. (3)}$$

(-ve forces signify a change in direction)

b) $F(N)$



(1)

8) a) $F = \frac{GMm}{r^2}$ • r is the distance between 2 masses M and m
 • G is the universal constant of gravitation
 • F Gravitational force of attraction. (1)

b) $mg = \frac{GMm}{R^2} \Rightarrow g = \frac{GM}{R^2}$

Force due to gravity = gravitational force. (2)

c) $g = \frac{GM}{R^2} = \frac{6.67 \times 10^{-11} \times 8 \times 10^{25}}{(9200 \times 10^3)^2} = \underline{\underline{63 \text{ N kg}^{-1}}}$

(2)

(7)

● 8) d) Density = $\frac{\text{mass}}{\text{Volume}}$, $\rho = \frac{m}{V}$

$$\Rightarrow \text{Density} = \frac{8 \times 10^{25}}{3.26 \times 10^{21}} \quad V = \frac{4}{3} \pi r^3$$

$$\Rightarrow \text{Density} = 24,540 \text{ kg m}^{-3}$$

$$= 2.45 \times 10^4 \text{ kg m}^{-3}$$

$$V = 3.26 \times 10^{21} \text{ m}^3$$

(3)

● 9) a) 'Time dilation' is the time measured by a stationary observer in a different (2) frame of reference in an object moving at speeds approaching the speed of light.

b) $t' = \frac{t}{\sqrt{1 - \frac{v^2}{c^2}}} = \frac{4.3}{\sqrt{1 - \frac{(0.95c)^2}{c^2}}} = \frac{4.3}{\sqrt{1 - 0.95^2}}$

$$t' = \frac{4.3}{\sqrt{1 - 0.90}} = \frac{4.3}{\sqrt{0.10}} = 13.6 \text{ years.}$$

(3)

c) $L' = L \times \sqrt{1 - \frac{v^2}{c^2}}$

4.3 light years

$$d = vxt = 3 \times 10^8 \times (365 \times 24 \times 60 \times 60)$$

$$\Rightarrow 1 \text{ light year} = 9.46 \times 10^{15} \text{ m.}$$

$$\Rightarrow 4.3 \text{ light years} = 4.3 \times 9.46 \times 10^{15} \text{ m}$$

$$L = 4.1 \times 10^{16} \text{ m}$$

(8)

$$l' = l \times \sqrt{1 - \frac{v^2}{c^2}}$$

$$\Rightarrow l' = 4.1 \times 10^{16} \times \sqrt{1 - \frac{(0.95c)^2}{c^2}} = 4.1 \times 10^{16} \times \sqrt{1 - 0.90}$$

$$\Rightarrow l' = 4.1 \times 10^{16} \times \sqrt{0.1} = \underline{1.3 \times 10^{16} \text{ m}} \quad (3)$$

10) a) 'Length contraction' is the length of an measured by a stationary observer in a different frame of reference as the object moves at speeds approaching the speed of light. (2)

$$b) l' = l \times \sqrt{1 - \frac{v^2}{c^2}}$$

$$\Rightarrow l' = 65 \times \sqrt{1 - \frac{(2.3 \times 10^8)^2}{(3 \times 10^8)^2}}$$

$$\Rightarrow l' = 65 \times \sqrt{1 - 0.588} = 65 \times \sqrt{0.412}$$

$$\Rightarrow \underline{l' = 41.7 \text{ m.}} \quad (3)$$

11) a) Doppler Effect looks at the frequency of sound picked up by a stationary observer when a moving sound source moves towards or away from them. (2)

$$b) f_{\text{obs}} = f_s \left(\frac{V}{V - Vs} \right) = 277 \left(\frac{340}{340 - 16} \right)$$

$$\Rightarrow f_{\text{obs}} = 277 \times \frac{340}{324} = \underline{291 \text{ Hz}} \quad (3)$$

(9)

● 12) a) $Z = \frac{\lambda_{\text{obs}} - \lambda_{\text{REST}}}{\lambda_{\text{REST}}} = \frac{663 - 656}{656}$

$$\Rightarrow Z = \frac{7}{656} = \underline{+0.011} \quad (3)$$

b) $Z = \frac{V}{C} \Rightarrow V = ZC \quad (3)$

$$\Rightarrow V = 0.011 \times 3 \times 10^8 = \underline{3.3 \times 10^6 \text{ ms}^{-1}}$$

13) a) Graph (on the next page). (3)

b) $V = H_0 d \Rightarrow H_0 = \frac{V}{d} = \text{gradient of the graph.}$

$$m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{(104 - 64) \times 10^3}{(4.1 - 2.5) \times 10^{22}}$$

$$\Rightarrow m = \frac{40 \times 10^{+3}}{1.6 \times 10^{22}} = 2.5 \times 10^{-18-1}$$

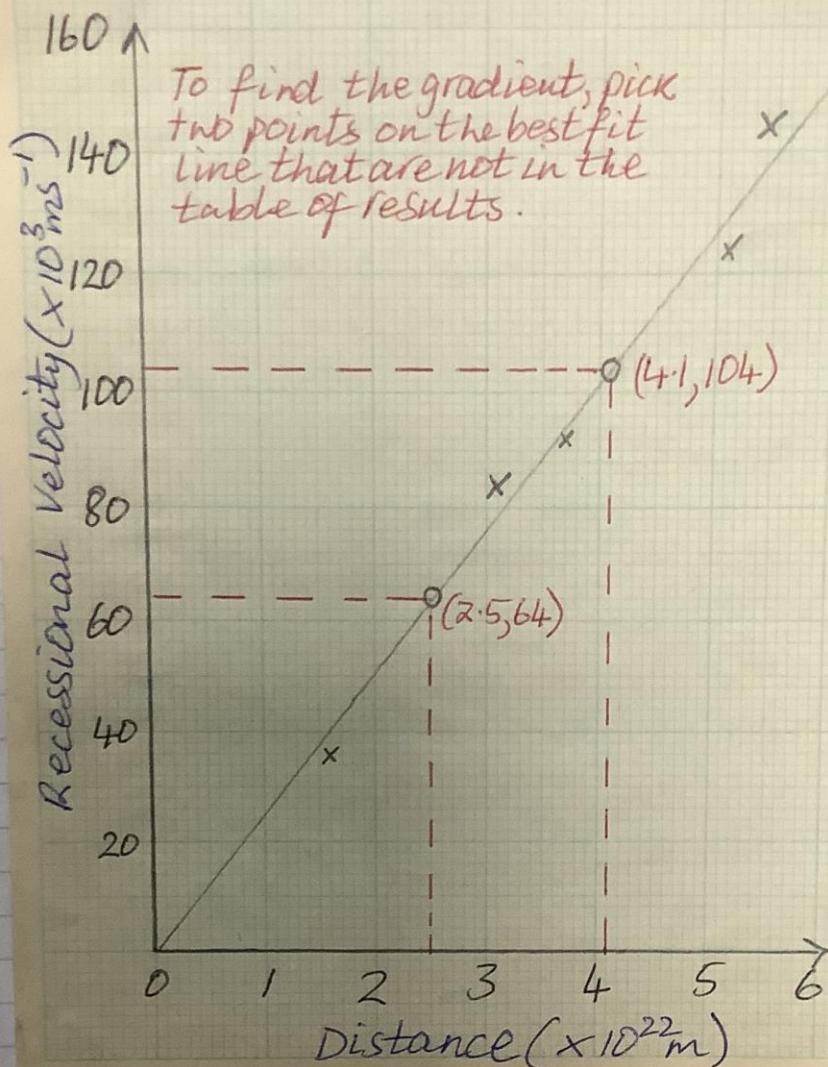
$$\therefore \underline{H_0 = 2.5 \times 10^{-18-1} \text{ s}} \quad (3)$$

c) The Hubble's Law constant has changed a little over the years due to the advancement in technology of the measuring equipment. (1)

(13)

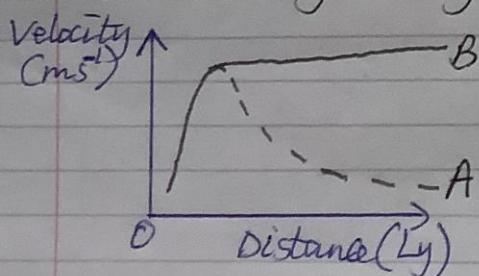
(Con'td)

(10)



- 14) • The expected orbital velocity of galaxies (B) is greater than expected (A).
 • Conclusion - There is additional mass in the galaxy that we cannot observe.

(3)



TOTAL MARKS = 100