Marks	MC	Written	Total
Forces & Motion	8	17	25
Energy & Momentum	10	11	21
Electric & Magnetic Fields	8	10	18
Light Interference	10	7	17
Modern Physics	14	5	19

SPH 4UI Exam Review Answers: Written

1. $46.8 \frac{km}{h}$
2. $39°$
3. 4.6×10^4 N [72° from original direction]
4. 45 cm from small mass
5. 9×10^{-5} N
7. T = 45.23, $a = 0.97 \frac{m}{s^2}$
8. 4.3 cm
9. $145 \frac{m}{s}$ [N 55° W]
10. $1 \times 10^{13} \frac{m^3}{s^2}$
12. a) 26 cm from entry point
    b) 0 cm
14. $6.8 \times 10^5 \frac{m}{s}$

MC Q's

~~1.~~
2. C
3. B
4. D
5. B
6. C
7. C
8. C
9. C
10. B
11. B
12. E
13. E
14. D
15. D
16. D
17. D
18. D
19. D
20. B
21. E
22. D
23. A
24. A
25. D
26. D
27. E
~~28. D~~
29. B
30. E
31. C
32. B
33. C
34. D
35. B
36. B
37. A
38. E
39. E
40. D
41. B
42. A
43. D
44. D
45. B

Written Solutions:

1) Speeder: $d = D = 1100\ m$, $V = V$, $t = T$

Police: Accel: $d = d_A$, $t_a = 15\ s$ | Uniform: $V = 150\ \frac{km}{h} = 41.7\ \frac{m}{s}$, $d = 1100 - d_A$, $t = T - t_a$

Police

Accel phase

$v_i = 0$

$v_f = 41.7\ \frac{m}{s}$

$d = d_A$

$t = 15\ s$

$d = \left(\frac{v_i + v_f}{2}\right)t$

$= (20.85)(15)$

$= 312.5\ m$

unifom phase

$V = 41.7\ \frac{m}{s}$

$d = 1100 - 312.5$

$= 787.5\ m$

$t = T - 15$

$d = vt$

$787.5 = 41.7(T - 15)$

$787.5 = 41.7T - 625$

$41.7T = 1412.5$

$T = 33.9\ s$

Speeder

$d = 1100\ m$

$V = V$

$t = T = 33.9\ s$

$v = \frac{d}{t}$

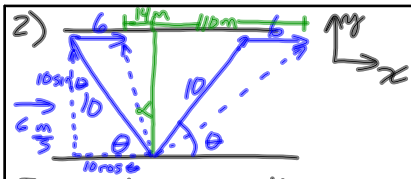
$= \frac{1100}{33.9}$

$= 32.45\ \frac{m}{s}$

$= 116.8\ \frac{km}{h}$

$\therefore 46.8\ \frac{km}{h}$ over limit

2)



In y-dir. v_y is the same in both cases (since y-comp. of $\vec{v}$ is from swimmer only) $\therefore v_y = 10\sin\theta$

$\therefore t$ is the same in both cases

Upstream

$\vec{v}_{x_u} = -10\cos\theta + 6$

$d_{x_u} = -14$ m

Downstream

$\vec{v}_{x_D} = 10\cos\theta + 6$

$d_{x_D} = 110$ m

$v = \frac{d}{t}$

$-10\cos\theta + 6 = \frac{-14}{t}$ ① and $10\cos\theta + 6 = \frac{110}{t}$ ②

or $10\cos\theta = \frac{110}{t} - 6$

$\therefore -\left(\frac{110}{t} - 6\right) + 6 = \frac{-14}{t}$

$\frac{-110}{t} + 12 = \frac{-14}{t}$

$12 = \frac{-14 + 110}{t}$

$t = \frac{96}{12} = 8$ s

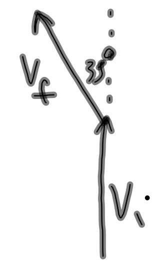
Sub into ① or ②

$10\cos\theta = \frac{110}{8} - 6$

$= 13.75 - 6$

$\cos\theta = \frac{7.75}{10}$

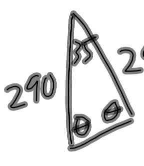
$\theta = 39°$



$|\vec{V}_i| = |\vec{V}_f| = 290 \frac{m}{s}$

To get $\vec{F}$, need $\vec{a}$

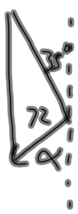
$\therefore$ need $\Delta\vec{v}$



isosceles $\therefore$ 2 ∡ the same

$180 = 35 + 2\theta$

$\theta = 72°$



$\alpha = 180 - 35 - 72$

$= 73°$

$\Delta\vec{v} = \vec{v}_f - \vec{v}_i$

$= \vec{v}_f + (-\vec{v}_i)$

$-\vec{V}_i \to 290$

$|\Delta\vec{v}|^2 = 290^2 + 290^2 - 2(290)(290)\cos 35°$

⋮

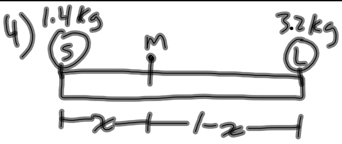
$|\Delta\vec{v}| = 174 \frac{m}{s}$

$\Delta\vec{v} = 174 \frac{m}{s}$ [73° back from orig. direction]

$\therefore \vec{a} = \frac{174 \frac{m}{s}}{3.2 \times 10^{-4} s}$ [↓]

$\vec{a} = 4.6 \times 10^4$ N [↓]

4)



$F_s = \frac{2}{3} F_L$ ($\frac{1}{3}$ less)

$$F_s = \frac{G m_s m}{x^2} \qquad F_L = \frac{G m_L m}{(1-x)^2}$$

$$\therefore \frac{G m_s m}{x^2} = \frac{2}{3}\frac{G m_L m}{(1-x)^2}$$

$$\frac{m_s}{x^2} = \frac{2}{3}\frac{m_L}{1-2x+x^2}$$

$$1-2x+x^2 = \frac{2}{3}\left(\frac{m_L}{m_s}\right)x^2$$

$$1-2x+x^2 = \frac{2}{3}\left(\frac{3.2}{1.4}\right)x^2$$

$$= 1.52x^2$$

$$\therefore 0 = 0.52x^2 + 2x - 1$$

$$x = \frac{-2 \pm \sqrt{2^2 - 4(0.52)(-1)}}{2(0.52)}$$

$x = 0.45$ m or ~~-4.27 m~~ Not on metre stick

$\therefore$ sensor is placed at 45 cm

5) Nuclear force must balance with electrical force & gravitational force

repulsion $F_e = \frac{k q_1 q_2}{r^2}$

$$= \frac{(9\times10^{9})(1.602\times10^{-19})^2}{(1.6\times10^{-12})^2}$$

$$= 9.02\times10^{-5}\ N$$

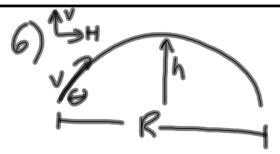
attraction $F_g = \frac{G m_1 m_2}{r^2} = \frac{(6.67\times10^{-11})(1.67\times10^{-27})^2}{(1.6\times10^{-12})^2}$

$$= 7.27\times10^{-41}\ N$$

(Negligible compared to F_e)

$$\therefore F_n = F_e = 9.02\times10^{-5}\ N$$

6)



For max height...

Vert.

$v_i = v\sin\theta$
$v_f = 0$
$a = -g$
$d = h$

$v_f^2 = v_i^2 + 2ad$
$0 = v^2\sin^2\theta - 2gh$
$\therefore v^2\sin^2\theta = 2gh$

$h = \frac{v^2\sin^2\theta}{2g}$

For Range

Vert.

$v_i = v\sin\theta$
$a = -g$
$d = 0$
$t = T$

Hor.

$d = R$
$v = v\cos\theta$
$t = T$

$d = v_i t + \frac{1}{2}at^2$
$0 = v\sin\theta T - \frac{gT^2}{2}$

$\therefore T = 0$ or $v\sin\theta = \frac{gT}{2}$

so $T = \frac{2v\sin\theta}{g}$

$d = vt$
$R = v\cos\theta\left(\frac{2v\sin\theta}{g}\right)$
$R = \frac{2v^2\cos\theta\sin\theta}{g}$

But for max Range $\theta = 45°$!

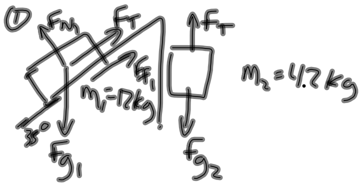
$(\therefore \sin\theta = \cos\theta$

so $R = \frac{2v^2\sin^2\theta}{g}$ an $h = \frac{v^2\sin^2\theta}{2g}$

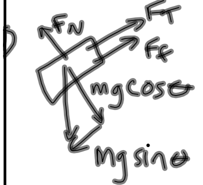
$\frac{R}{h} = \frac{\frac{2v^2\sin^2\theta}{g}}{\frac{v^2\sin^2\theta}{2g}}$

$= \frac{2}{\frac{1}{2}}$

$\frac{R}{h} = 4$ → $\therefore R$ is $4 \times h$



$m_2 = 4.2kg$



y-dir

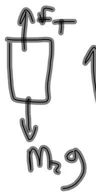
$F_{NET} = 0$
$F_{NET} = F_N - mg\cos\theta$
$\therefore F_N = mg\cos\theta$

x-dir

$F_{NET} = m_1 a$
$F_{NET} = -F_T - F_f - mg\sin\theta$

① $m a = -F_T - \mu m g\cos\theta + m_1 g\sin\theta$

②



$F_{NET} = m_2 g - F_T$
$F_{NET} = m_2 a$
$\therefore m_2 a = m_2 g - F_T$

③ $F_T = m_2 g - m_2 a$

Sub ③ into ①

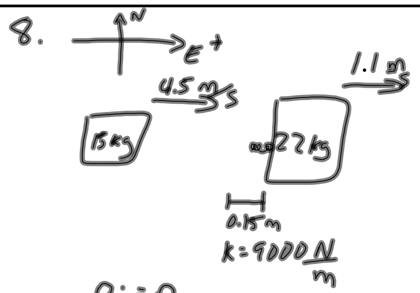
$m_1 a = -(m_2 g + m_2 a) - \mu m_1 g\cos\theta + m_1 g\sin\theta$

$12a = -4.2g - 4.2a - (0.1)(12)g\cos 35 + 12g\sin 35$

$16.2a = -41.16 - 10.6 + 67.5$

$a = 15.7$ ... $F_T = 41.16 + (4.2)(a)$

8.



At closest approach

$V_{15} = V_{22} = V$

$$p_i = p_f$$

$$(15)(4.5) + (22)(1.1) = (15 + 22)V$$

$$67.5 + 24.2 = 37V$$

$$91.7 = 37V$$

$$V = 2.48 \frac{m}{s}$$

$$E_i = E_f$$

$$E_{Ki_{15}} + E_{Ki_{22}} = E_{K_f} + E_s$$

$$\frac{1}{2}(15)(4.5)^2 + \frac{1}{2}(22)(1.1)^2 = \frac{1}{2}(37)(2.48)^2 + \frac{1}{2}(9000)x^2$$

$$151.875 + 13.31 = 113.782 + 4500x^2$$

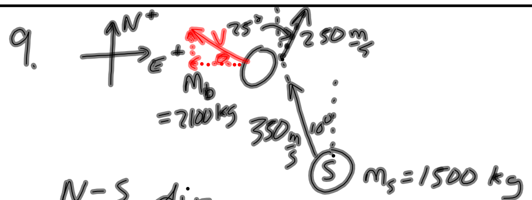
$$51.40 = 4500x^2$$

$$x^2 = 0.0114$$

$$x \approx 0.107 \text{ m} = 10.7 \text{ cm}$$

Since the spring is 15 cm long, and it compresses 10.7 cm, then the carts get to within 4.3 cm

9.



N-S dir

$$p_i = p_f$$

$$(1500)(350)\cos 10^\circ = (1500)(250)\cos 25 + (2100)v\sin\theta$$

$$517\,024 = 339\,865 + 2100v\sin\theta$$

$$\boxed{177\,159 = 2100v\sin\theta} \quad (1)$$

E-W dir

$$-(1500)(350)\sin 10 = (1500)(250)\sin 25 - 2100v\cos\theta$$

$$-91165 = 158\,482 - 2100v\cos\theta$$

$$\boxed{2100v\cos\theta = 249\,647} \quad (2)$$

$$\frac{(1)}{(2)} \quad \frac{2100v\sin\theta}{2100v\cos\theta} = \frac{177\,159}{249\,647}$$

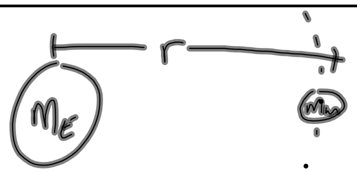
$$\tan\theta = 0.7096$$

$$\theta = 35^\circ$$

$$2100v\sin 35 = 177159$$

$$V = 147 \frac{m}{s}$$

10.



On Moon

$$F_{NET} = F_c = \frac{4\pi^2 r m_m}{T^2}$$

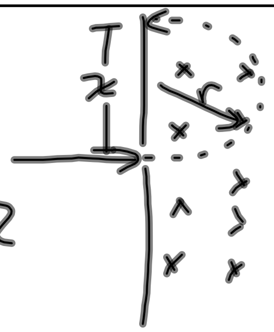
$$F_{NET} = \frac{G M_E m_m}{r^2}$$

$$\therefore \frac{4\pi^2 r m_m}{T^2} = \frac{G M_E m_m}{r^2}$$

$$\frac{r^3}{T^2} = \boxed{\frac{G M_E}{4\pi^2}}$$ → Kepler's Constant for Earth

$$K = \frac{(6.67\times10^{-11})(5.98\times10^{24})}{4\pi^2} = 1.0\times10^{13}\ \frac{m^3}{s^2}$$

#12



$$F_c = F_m$$

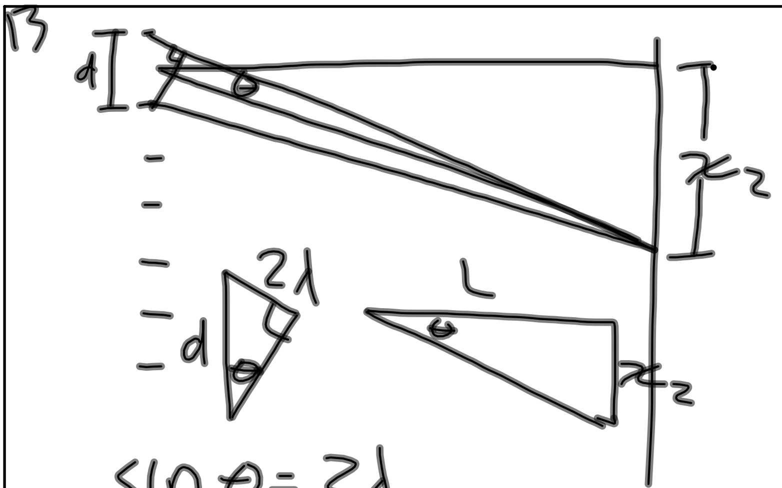
$$\frac{mv^2}{r} = qvB$$

$$r = \frac{mv}{qB} = \frac{(1.67\times10^{-27})(5\times10^{6})}{(1.6\times10^{-19})(0.4)} = 0.13\,m$$

$$x = 2r = 0.26\,m$$ ← electron

Neutron → $q = 0$ ∴ not bent at all!

13



For 2nd maxima

PD = 2λ

$$\sin\theta = \frac{2\lambda}{d}$$

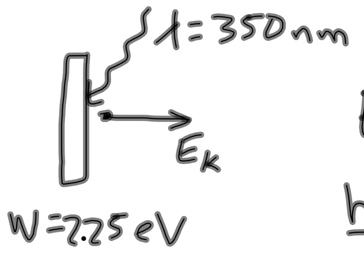
$$\tan\theta = \frac{x_2}{L}$$

If θ is small (may not be with diffraction grating) then $\tan\theta = \sin\theta$

$$\frac{x_2}{L} = \frac{2\lambda}{d}$$

$$x_2 = \frac{2\lambda L}{d}$$

14.



$$E_p = E_k + W$$

$$\frac{hc}{\lambda} = E_k + 2.25$$

$$\frac{1.243\times10^{-6}}{3.5\times10^{-7}} = E_k + 2.25$$

$$E_k = 3.55 - 2.25$$

$$= 1.30\ eV \quad \times 1.6\times10^{-19}\ \frac{J}{eV}$$

$$= 2.1\times10^{-19}\ J$$

$$\frac{1}{2}m_e v^2 = 2.1\times10^{-19}$$

$$v^2 = \frac{2(2.1\times10^{-19})}{9.11\times10^{-31}}$$

$$= 4.6\times10^{11}$$

$$v = 6.8\times10^{5}\ \frac{m}{s}$$