G12 Physics Mock 2022- Paper 1 (Solutions)

MCQ

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
B	B	D	C	D	C	B	C	B	C	C	B	D	D	D
16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
A	B	C	C	C	C	D	C	C	C	C	B	B	D	A
31	32	33												
D	A	B												

Question 1 (4 marks)

(a) $(m_{milktea}c_{milktea} + \mathrm{C_{cup}})\Delta\mathrm{T} = \Delta m_{ice} \times l_f$

$(15 - 0)(330)(4.2) + (15 - 0)(300) = \Delta m\ (3.34 \times 10^5)$ 1M

$\Delta m = 0.0757$ kg (= 75.7 g) (3 s. f.) 1A

(b) Cooling rate depends on temperature difference. 2A (any two @1A)
Water at 0 °C increases its temperature when milk-tea is put into the water.
(OR melting ice remains at 0 °C when milk-tea is put into the water.)
Temperature difference between water and milk-tea decreases over time rapidly.
(OR Temperature difference between melting ice and water decreases over time slowly.)

Question 2 (7 marks)

(a) $PV = nRT \rightarrow (290 \times 10^3)(0.031) = n(8.31)(17 + 273)$ 1M

$n = 3.73045 = 3.73$ mol 1A

(b) (i) 2A (any two @1A)
- The volume and temperature of the gas remains constant.
- The collision frequency increases as n increases.
- The average force acing on the tyre wall increases

(ii) Let ΔP and Δn be the increase in P and n at each stroke respectively.

$$\Delta P = \Delta n \frac{RT}{V} = \frac{(0.012)(8.31)(17 + 273)}{0.031}$$ 1M

$$\Delta P = 932.86 \text{ Pa}$$ 1M

No. of strokes= $\frac{(500-290)\times 10^3}{932.86} = 225.1$

The number of strokes required is 226 1A

OR At $P = 500$ kPa: $(500 \times 10^3)(0.031) = n'(8.31)(17 + 273)$ (1M)

$n' = 6.4318$ mol (1M)

No. of strokes= $\frac{6.4318-3.73}{0.012} = 225.1$

The number of strokes required is 226 (1A)

Question 3 (11 marks)

(a) $s_A = ut = (10)(8) = 80$ m; $d_A = 190 - 80 = 110$ m — 1A

$s_B = (\frac{u+v}{2})t = (\frac{8+12}{2})(8) = 80$ m; $d_B = 200 - 80 = 120$ m — 1M, 1A

(b) (i) $110 - 10t = 120 - 12t \Rightarrow t = 5$ s — 1M, 1A

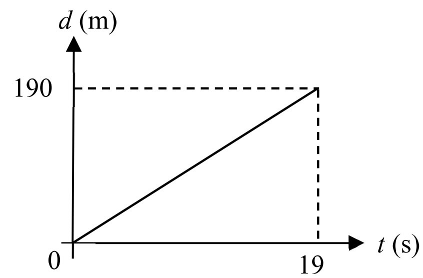
(ii) $d = 110 - 10(5)$ or $d = 120 - 12(5) \Rightarrow d = 60$ m — 1A

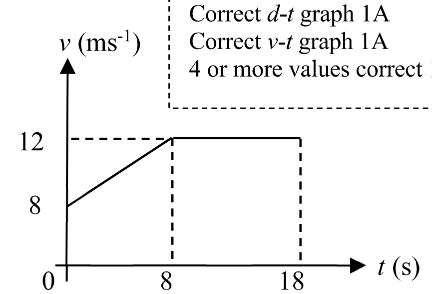
(c) (i) $s_A = u_A t_A \Rightarrow 60 = (10)t_A \Rightarrow t_A = 6$ s; $s_B = u_B t_B \Rightarrow 60 = (12)t_B \Rightarrow t_B = 5$ s — 1A

B wins the race by 6 – 5 = 1 s. — 1A

(ii) $d = 60 - (10)(5) = 10$ m

(d)





Overtaking at 13 s

Correct *d*-*t* graph 1A
Correct *v*-*t* graph 1A
4 or more values correct 1A

1A
1A
1A

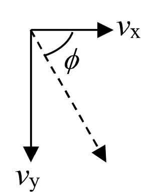
Question 4 (11 marks)

(a) (i) $S_y = u_y t - \frac{1}{2}gt^2 \Rightarrow 1 = (u\sin\theta)T - \frac{1}{2}gT^2$ — 1M

$\therefore u\sin\theta = \frac{1 + \frac{1}{2}gT^2}{T} = \frac{1}{T} + \frac{gT}{2}$ — 1M

(ii) $\tan\phi = \frac{v_y}{v_x} \Rightarrow \tan(-60°) = \frac{u\sin\theta - gT}{u\cos\theta} \Rightarrow \tan 60° = -\frac{u\sin\theta - gT}{u\cos\theta}$ — 1M

$\therefore \tan 30° = \frac{1}{\tan 60°} = -\frac{u\cos\theta}{u\sin\theta - gT}$ — 1M



(b) The angle ϕ is negative / below horizontal / anticlockwise. — 1A
OR
The vertical velocity v_y is negative / downwards.

(c) From (i), $u\sin\theta = \frac{1}{T} + \frac{gT}{2}$; $s_x = u_x t \Rightarrow 4 = (u\cos\theta)T \Rightarrow u\cos\theta = \frac{4}{T}$

$\therefore \tan 30° = -\frac{u\cos\theta}{u\sin\theta - gT} \Rightarrow \frac{1}{\sqrt{3}} = -\frac{4/T}{(\frac{1}{T} + \frac{gT}{2}) - gT} \Rightarrow \frac{1}{\sqrt{3}} = -\frac{8}{2 - gT^2}$ — 1M

$$T^2 = \frac{2+8\sqrt{3}}{9.81} \Rightarrow T = 1.2714 \approx 1.27 \text{ s}$$ 1A

(d) $u\sin\theta = \frac{1}{T} + \frac{gT}{2}$; $u\cos\theta = \frac{4}{T}$ 1M

$$\tan\theta = \frac{u\sin\theta}{u\cos\theta} = \frac{\frac{1}{T}+\frac{gT}{2}}{4/T} = \frac{2+gT^2}{8} = \frac{2+(9.81)(1.2714^2)}{8}$$ 1M

$\therefore \theta = 65.868° \approx 66°$

(e) $$R = u_x t = (u\cos\theta)(\frac{2u\sin\theta}{g}) = \frac{u^2\sin 2\theta}{g}$$

$$4 = \frac{8.66^2 \sin 2\theta}{9.81} \Rightarrow \sin 2\theta = 0.52323 \Rightarrow \theta = 15.8° \text{ or } \theta = 74.2°$$ 1M

Since Natalie increases her angle of projection from $66°$,
the new projection angle is $74.2°$. 1A

Question 5 (9 marks)

(a) $g_{moon} = \frac{GM_{moon}}{R^2_{moon}}$, $g_{earth} = \frac{GM_{earth}}{R^2_{earth}}$ 1M

$$g_{moon} = g_{earth}(\frac{M_{moon}}{M_{earth}})(\frac{R^2_{earth}}{R^2_{moon}}) = 9.81(\frac{1}{81})(3.67^2) = 1.6312 \approx 1.63 \text{ ms}^{-2}$$ 1A

(b) $$\frac{GMm}{r^2} = m\omega^2 r \Rightarrow \frac{GM}{r^3} = (\frac{2\pi}{T})^2 \Rightarrow r^3 = \frac{GM}{4\pi^2}T^2$$ 1M

On earth's surface, $g = \frac{GM}{R^2} \Rightarrow GM = gR^2$.

$$r^3 = \frac{gR^2}{4\pi^2}T^2 = \frac{(9.81)(6.37\times10^6)^2}{4\pi^2}(27.5\times24\times3600)^2 \Rightarrow r = 3.847\times10^8 \text{ m}$$ 1M

$$\therefore \frac{r}{R} = \frac{3.847\times10^8}{6.37\times10^6} = 60.4 \approx 60$$ 1A

(c) (i) $\omega_{earth} = \frac{2\pi}{T_{earth}} = \frac{\theta}{t}$; $\omega_{satellite} = \frac{2\pi}{T_{satellite}} = \frac{2\pi+\theta}{t}$ (θ in radian) 1M

At the same time t, $T_{earth}\theta = T_{satellite}(2\pi+\theta) \Rightarrow 86400\theta = 5400(2\pi+\theta)$ 1A

$\therefore \theta = \frac{2}{15}\pi$ (rad) = 24°

Accept: 24 θ = 1.5 (360º + θ)

(ii) $$\frac{2\pi}{T_{earth}} = \frac{\theta}{t} \Rightarrow \frac{2\pi}{86400} = \frac{2\pi/15}{t} \Rightarrow t = \frac{86400}{15} = 57600 \text{ s (96 min)}$$ 1M

$12:00 \text{ pm} \xrightarrow{96 \text{ min}} 13:36 \text{ pm}$ 1A

After 96 minutes, the new time is 13:36 pm.

Question 6 (8 marks)

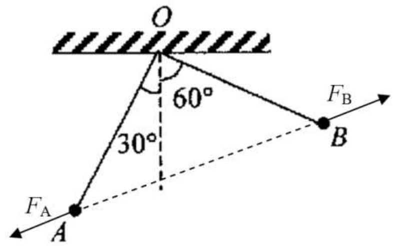
(a)	(i)	At C, $1.09 \sin\phi = (1)\sin(90° - 9°)$ $\phi = 64.97673 = 65.0°$ (3 s. f.)	1M 1A
	(ii)	At B, $1.7 \sin\theta_g = 1.09 \sin\phi$ $\theta_g = 35.5204°$ $\theta = 90 - \theta_g = 54.47957 = 54.5°$	1M 1A
(b)	(i)	$r = \theta + i - 90°$	1A
	(ii)	Let critical angle at B be c $c = \sin^{-1}\left(\frac{1.09}{1.70}\right) = 39.87960°$ For total internal reflection to occur, $i > c \quad \rightarrow \quad r = \theta + i - 90° > \theta + c - 90°$ At A, $\sin\alpha = 1.7 \sin r$ $> 1.7\sin(\theta + c - 90°)$ $= 1.7\sin(54.47957° + 39.87960° - 90°)$ $= 0.12921$ $\therefore \alpha > 7.42420 = 7.42°$	 1M 1M 1A

Question 7 (6 marks)

(a)		Path difference of waves from A and B to probe R varies along OU. Constructive and destructive interference occur alternatively to give maxima and minima.	1A 1A
(b)	(i)	$\Delta_{x=10} = 52.2 - 50.2 = (1)\lambda$ $\lambda = 2$ cm **OR** $\Delta_{x=22} = 56.8 - 52.8 = (2)\lambda$ $\lambda = 2$ cm	1M 1A (1M) (1A)
	(ii)	$f = \frac{3\times10^8}{0.02} = 1.5 \times 10^{10}$ Hz	1A
	(iii)	- Fringe separation is not even. - θ is not small or $D \gg a$ is not true - Small angle approximation cannot be applied.	 1A (any 1)

Question 8 (10 marks)

(a) (See diagram) 1A



They are action and reaction pair / repulsive / non-contact forces. 1A

(b) $r = \sqrt{0.05^2 + 0.05^2} = \sqrt{0.005} = 0.07071$ m (7.07 cm) 1A

1M

$$F = \frac{Q_1 Q_2}{4\pi\varepsilon_o r^2} = \frac{(5\times10^{-7})(8\times10^{-7})}{4\pi(8.85\times10^{-12})(0.005)} = 0.719344 \approx 0.719 \text{ N}$$ 1A

(c) For F_B, the perpendicular distance $d_\perp = 0.05\sin 45° = 0.035355$ m 1A

(or $d_\perp = \frac{r}{2} = \frac{0.07071}{2}$)

Taking moment about O, $F_B d_\perp = mgl\sin\theta$

$(0.719344)(0.035355) = m(9.81)(0.05)\sin 60°$ 1M

$\therefore m = 0.05987 \approx 0.0599$ kg (accept 0.06 kg) 1A

(d) $F_B d_\perp = mgl\sin 60°$; $F_A d_\perp = Mgl\sin 30°$

Since $F_A = F_B$, $mgl\sin 60° = Mgl\sin 30°$ 1M

$$\frac{m}{M} = \frac{gl\sin 30°}{gl\sin 60°} = \frac{1/2}{\sqrt{3}/2} = \frac{1}{\sqrt{3}} = 0.577$$ 1A

Question 9 (12 marks)

(a) $\frac{N_P}{N_S} = \frac{V_P}{V_S} = \frac{300}{1500} = 0.2$ (1:5) 1A

(b) $P = VI \Rightarrow 30000 = 1500I \Rightarrow I = 20$ A 1A

(c) $\frac{I^2 r}{P_{in}} \times 100\% = \frac{(20^2)(0.5)}{30000} \times 100\% = 0.667\%$ 1M 1A

(d) $R \propto l \Rightarrow \frac{0.25}{10000} = \frac{R_2}{0.05} \Rightarrow R_2 = 1.25\times10^{-6}\ \Omega$ 1M 1A

(e) $I_1 : I_2 = \frac{1}{R_1} : \frac{1}{R_2} = \frac{1}{10^6} : \frac{1}{1.25\times10^{-6}} = 1.25\times10^{-12} : 1$ 1M 1A

(f) $I_{bird} = I_1 = 20 \times \frac{1.25\times10^{-12}}{1.25\times10^{-12}+1} = 2.5\times10^{-11}\text{A} = 2.5\times10^{-8}\text{mA} << 100 \text{ mA}$ 1M

Since the current is much smaller than 100 mA, the bird will not get an electric shock. 1A

(g)	The resistance of the bird R_1 is much larger compared to that of the segment R_2. ($10^6\ \Omega >> 10^{-6}\ \Omega$) The total resistance / power loss of the transmission cable with or without the birds is practically the same. OR The branch current I_1 (I_{bird}) is negligible (10^{-11} A << 20 A). The current / useful power passing through the transmission cable is practically the same. The efficiency of the transmission system would not be affected practically	1A 1A

Question 10 (6 marks)

(a)	Alpha radiation has a low penetrating power. (Alpha radiation cannot pass through the metal container)	1A
(b)	$a = 234$; $b = 90$; $c = 4$; $d = 2$	1A (for all correct)
(c)	(i) $A = (9.3\times10^{10})(0.5)^{\frac{30}{88}}$ or $A = (9.3\times10^{10})e^{-30\times\frac{\ln 2}{88}}$ $A = 7.342756\times10^{10} = 7.34\times10^{10}$ Bq (3 s. f.) (ii) $P = \frac{\text{(number of decay)(energy released per decay)}}{\text{time}}$ $= 7.34\times10^{10}\times5.5$ MeV s^{-1} $= 7.34\times10^{10}\times5.5\times10^{6}\times1.6\times10^{-19}$ J s^{-1} $= 0.0646$ W $= 64.6$ mW (3 s. f.)	1M 1A 1M 1A