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HKMIA
Hong Kong Multiple Intelligence Association

HKDSE MOCK EXAMINATION 2022

Physics

Marking Scheme

Marking Scheme

Paper I Section A

Question No.	Key	Question No.	Key
1.	D	26.	B
2.	B	27.	D
3.	B	28.	B
4.	C	29.	D
5.	B	30.	B
6.	D	31.	A
7.	B	32.	B
8.	B	33.	D
9.	B		
10.	A		
11.	C		
12.	A		
13	A		
14.	B		
15.	B		
16.	D		
17.	C		
18.	A		
19.	A		
20.	A		
21.	A		
22.	D		
23.	C		
24.	A		
25.	D		

Paper 1A: Suggested solution

1. D

$$\begin{aligned} E_{release} &= E_{absorb} \\ m_{ice}c_{ice}\Delta T + \Delta m l_f &= m_{water}c_{water}\Delta T_{water} \\ m_{ice}(2100)[0-(-20)]+(m_{ice}-0.03)(334\ 000) &= (0.08)(4200)(30-0) \\ m_{ice} &= \underline{\underline{0.0535 \text{ kg}}} \end{aligned}$$

2. B

3. B

$Q = mc\Delta T$

$Pt = mc\Delta T$

So, slope of T-t graph: $\dfrac{\Delta T}{t} = \dfrac{P}{mc}$

i.e. $\dfrac{\Delta T_x}{t_x} = \dfrac{P_x}{m_x c_x} = \dfrac{P}{mc}$

$\dfrac{\Delta T_y}{t_y} = \dfrac{P_y}{m_y c_y} = \dfrac{2P}{(2m)(2c)} = \dfrac{1}{2}(\dfrac{P}{mc}) = \dfrac{1}{2}(\dfrac{\Delta T_x}{t_x})$

4. C

Before the tap is opened,

According the equation of state $pV = nRT$

for container X, $pV = 2RT$

$$\frac{V}{RT} = \frac{2}{p} \qquad \text{... (1)}$$

After the tap is opened,

$$\begin{aligned} n_x + n_y &= n_x' + n_y' \\ 2 + 1 &= \frac{p'V}{RT} + \frac{p'V}{RT} \\ 3 &= 2p'(\frac{V}{RT}) \\ 3 &= 2p'(\frac{2}{p}) && \text{... by (1)} \\ p' &= \frac{3}{4}p \end{aligned}$$

5. **B**

Let the distance of the car travelled in one lap be d

$$\bar{c} = \frac{d_1 + d_2 + d_3}{t_1 + t_2 + t_3} \quad \Rightarrow \quad \bar{c} = \frac{d + d + d}{\frac{d}{c_1} + \frac{d}{c_2} + \frac{d}{c_3}}$$

$$\Rightarrow \quad \bar{c} = \frac{3}{\frac{1}{c_1} + \frac{1}{c_2} + \frac{1}{c_3}}$$

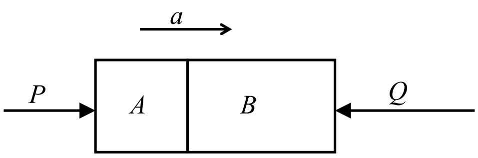
$$\Rightarrow \quad 77 = \frac{3}{\frac{1}{80} + \frac{1}{85} + \frac{1}{c_3}}$$

$\therefore \quad c_3 = \underline{\underline{68 \text{ km h}^{-1}}}$

6. **D**

$$P - Q = (m_A + m_B)a$$

$$\therefore \; a = \frac{P - Q}{m_A + m_B}$$

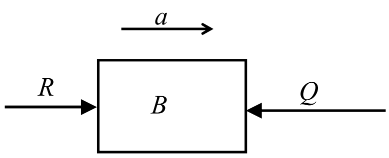


$$R - Q = (m_B)\, a$$

$$R = m_B\left(\frac{P - Q}{m_A + m_B}\right) + Q$$

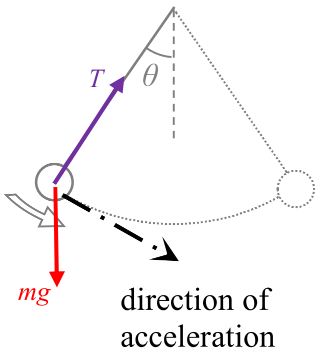
$$= (3m)\left(\frac{P - Q}{2m + 3m}\right) + Q$$

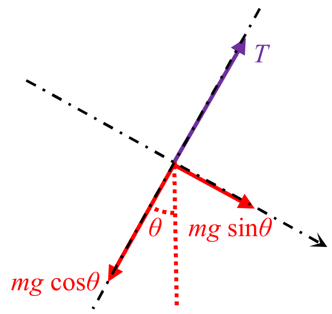
$$= \frac{3P + 2Q}{5}$$



7. **B**

For case (a):



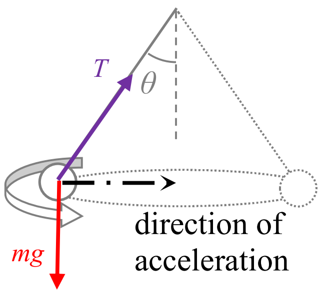


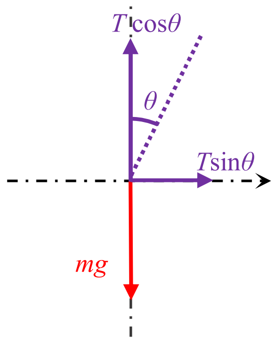
Free-body diagram

resolve forces along and perpendicular to the **direction of acceleration**

∴ For the case (a), $\boldsymbol{T = mg\cos\theta}$

For case (b):





Free-body diagram

resolve forces along and perpendicular to the direction of acceleration

∴ For the case (b), $T\cos\theta = mg$

i.e. $$T = \frac{mg}{\cos\theta}$$

8. B

	a	u	v	s	t
$X \rightarrow Y$	a	0	v_Y	s_1	t_1
$Y \rightarrow Z$	$-a$	v_Y	0	s_2	t_2

According to equations of uniform accelerating motion,

	$v^2 = u^2 + 2as$
from X to Y	$(v_Y)^2 = (0)^2 + 2(a)s_1$ $\Rightarrow \quad s_1 = \dfrac{{v_Y}^2}{2a}$
from Y to Z	$(0)^2 = (v_Y)^2 + 2(-a)s_2$ $\Rightarrow \quad s_2 = \dfrac{{v_Y}^2}{2a}$
therefore,	$s_1 = s_2$

from X to Y		from Y to Z
$s = ut + \dfrac{1}{2}at^2$ $\Rightarrow \quad s_1 = (0)t_1 + \dfrac{1}{2}(a){t_1}^2$ $\Rightarrow \quad s_1 = \dfrac{1}{2}a{t_1}^2$ $\Rightarrow \quad t_1 = \sqrt{\dfrac{2s_1}{a}}$ ……(1)	&	$s = vt - \dfrac{1}{2}at^2$ $s_2 = (0)t_2 - \dfrac{1}{2}(-a){t_2}^2$ $\Rightarrow \quad s_2 = \dfrac{1}{2}a{t_2}^2$ $\Rightarrow \quad t_2 = \sqrt{\dfrac{2s_2}{a}}$ ……(2)

The total time $t = t_1 + t_2$

$$= \sqrt{\frac{2s_1}{a}} + \sqrt{\frac{2s_2}{a}} \qquad \text{[from (1) and (2)]}$$

$$= \sqrt{\frac{2s_1}{a}} + \sqrt{\frac{2s_1}{a}} \qquad [\because \ s_1 = s_2]$$

$$= 2\sqrt{\frac{2s_1}{a}}$$

$$= 2\sqrt{\frac{s_1 + s_2}{a}} \qquad [\because \ s_1 = s_2]$$

$$= 2\sqrt{\frac{L}{a}}$$

$$= \underline{\underline{\sqrt{\frac{4L}{a}}}}$$

9. B

According to the formula for time of flight of a horizontal projectile motion, $t = \sqrt{\dfrac{2h}{g}}$

The flight times are same since the ball is projected with same height.

Reference:

		a $(m\ s^{-2})$	u $(m\ s^{-1})$	v $(m\ s^{-1})$	s (m)	t (s)
1st project	x	0	u_1		R_1	t_1
	y	-g	0		-h	
2sn project	x	0	u_2		R_2	t_2
	y	-g	0		-h	

	formula	proof
time of flight:	$t = \sqrt{\dfrac{2h}{g}}$	$s_y = u_y t_y + \dfrac{1}{2} a_y t_y^2$ $\Rightarrow -h = (0)(t) + \dfrac{1}{2}(\text{-}g)(t)^2$ $\Rightarrow t = \sqrt{\dfrac{2h}{g}}$
range of horizontal projectile motion:	$R = u\sqrt{\dfrac{2h}{g}}$	$s_x = u_x t_x + \dfrac{1}{2} a_x t_x^2$ $\Rightarrow R = (u)(t) + \dfrac{1}{2}(0)(t)^2$ $\Rightarrow R = u\sqrt{\dfrac{2h}{g}}$
speed of projectile reached the ground:	$v = \sqrt{u^2 + 2gh}$	$v = \sqrt{v_x^2 + v_y^2}$ $\Rightarrow v = \sqrt{(u_x + a_x t_x)^2 + (u_y + a_y t_y)^2}$ $\Rightarrow v = \sqrt{[(u) + (0)(t)]^2 + [(0) + (g)(t)]^2}$ $\Rightarrow v = \sqrt{u^2 + g^2 t^2}$ $\Rightarrow v = \sqrt{u^2 + g^2 (\sqrt{\dfrac{2h}{g}})^2}$ $\Rightarrow v = \sqrt{u^2 + 2gh}$

10. A

According to the law of conservation of energy,

$$\Delta KE_x + \Delta PE_x + \Delta KE_y + \Delta PE_y + W_f = 0$$

$$\Rightarrow \quad (\frac{1}{2}m_x v_x^{\ 2} - \frac{1}{2}m_x u_x^{\ 2}) + m_x g(\Delta h_x) + (\frac{1}{2}m_y v_y^{\ 2} - \frac{1}{2}m_y u_y^{\ 2}) + m_y g(\Delta h_y) + fs = 0$$

$$\Rightarrow \quad [KE_x - \frac{1}{2}m_x(0)^2] + m_x g(0) + [KE_y - \frac{1}{2}m_y(0)^2] + (2)(9.81)(-0.5) + (4)(0.5) = 0$$

$$\Rightarrow \quad KE_x + KE_y = (2)(9.81)(0.5) - (4)(0.5)$$

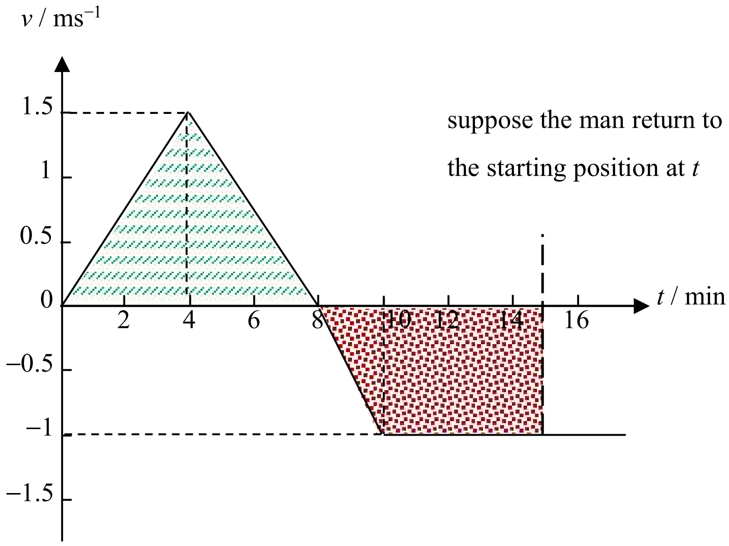
$$\Rightarrow KE_x + KE_y = \underline{\underline{7.81\,\text{J}}}$$

11. C

the area under the velocity-time graph means the displacement,

$$\frac{8 \times 1.5}{2} = \frac{[(t-8)+(t-10)] \times 1}{2}$$

$\therefore \ t = 15$



12. A

✓	(1)	g at the equator ($g_{\text{equator}} = g_{\text{pole}} - R_E\omega^2$) should be smaller than g at the poles.
×	(2)	$g_{\text{pole}} = \dfrac{GM_E}{R_E^{\ 2}}$ which is independent of angular speed ω.
×	(3)	$g_{\text{pole}} = \dfrac{GM_E}{R_E^{\ 2}} = \dfrac{G\rho(\frac{4}{3}\pi R_E^{\ 3})}{R_E^{\ 2}} = \dfrac{4}{3}\pi\rho G R_E$

13. A

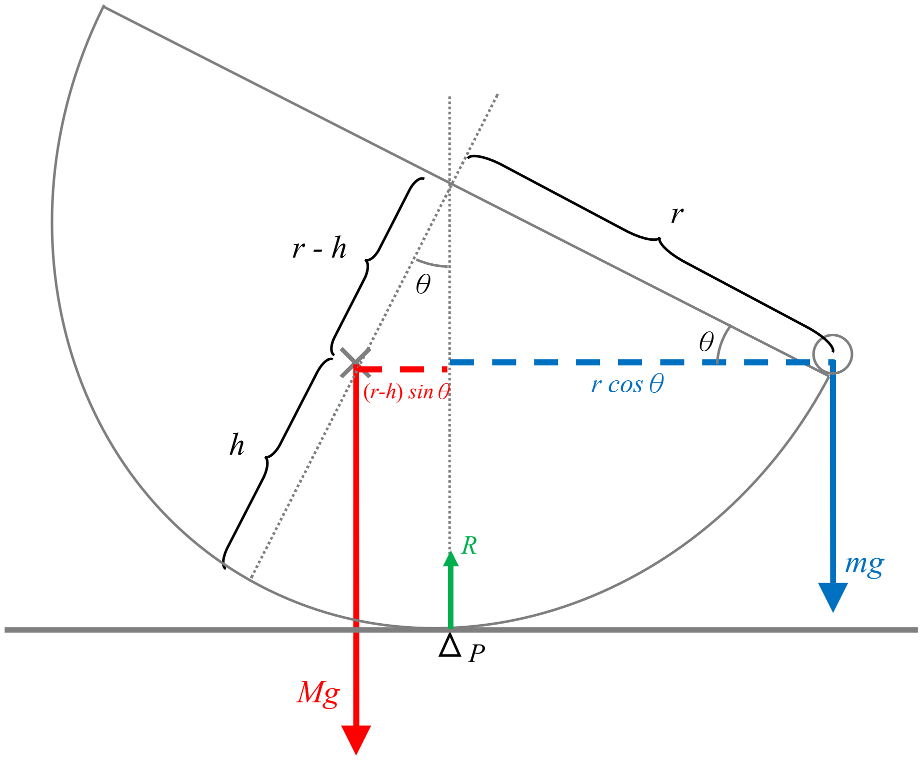
Take moment about point P,

$$Mg(r-h)\sin\theta = mg(r\cos\theta)$$

$$r-h=\frac{m(r\cos\theta)}{M\sin\theta}$$

$$r+\frac{mr\cos\theta}{M\sin\theta}=h$$

$$h=(1+\frac{m\cos\theta}{M\sin\theta})r$$



14. B

$$\frac{1}{u}+\frac{1}{v}=\frac{1}{f}$$

$$\frac{1}{x+f}+\frac{1}{f+y}=\frac{1}{f}$$

$$\frac{1}{5+f}+\frac{1}{f+5}=\frac{1}{f}$$

$\therefore\ f = 5$ cm

15. B

×	(1)	According to $\Delta y=\frac{\lambda D}{a}$, fringe separation Δy increases as wavelength increases. Since wavelength of red light is longer than green light, slit separation is increased if green light is replaced by red light. Therefore, number of fringes on the screen is decreased.
×	(2)	According to $\Delta y=\frac{\lambda D}{a}$, the width of slit is independent of the fringe separation.
✓	(3)	Δy is decreased when distance between the double-slit and the screen D is reduced. Therefore, number of fringes on the screen is increased.

16. D

Suppose the length of the string is L.

Originally,

Fundamental wavelength $\lambda_0 = 2L$, and fundamental frequency $f_0 = v/2L$.

If the length of the string is reduced by half,

the new fundamental wavelength $\lambda_0' = 2(L/2) = L$; and

the new fundamental frequency $f_0' = v/L$.

So, the frequencies of the stationary wave which formed on the string with k loops $f_k' = kf_0' = kv/L$.

However, the frequency of the vibrator remains unchanged.

i.e. $f_0 = f_k' \quad \Rightarrow \quad v/2L = kv/L$

$\Rightarrow \quad k = 1/2$ which is impossible.

17. C

✓	(1)	Sound wave is a mechanical wave.
×	(2)	Sound wave is longitudinal wave. The vibrating direction is parallel to the propagation direction.
✓	(3)	The speed of sound is higher as the wave travels from air to water. But the frequency of the sound is unchanged. According to $v=f\lambda$, the wavelength of a sound wave increases.

18. A

$$\frac{1}{u}+\frac{1}{v}=\frac{1}{f} \quad \Rightarrow \quad \frac{1}{0.2}+\frac{1}{v}=\frac{1}{-0.05}$$

$$\Rightarrow \quad \therefore v=-0.04\text{ m}$$

$$m=\frac{v}{u} \quad \Rightarrow \quad m=\frac{0.04}{0.2}=\underline{\underline{0.2}}$$

19. A

Constructive interference occurs at P, the path difference (p.d.) $\Delta x_P = \lambda$.

✓	(1)	$f \rightarrow f'=\frac{f}{2} \xrightarrow{\text{wave speed unchanged}} \lambda \rightarrow \lambda'=2\lambda$ $\Delta x_P = \lambda = \frac{\lambda'}{2}$ which means destructive interference occurs at P.
×	(2)	Only statement (2) does not affect the relationship between the p.d. and wavelength. i.e. $\Delta x_P = (n-\frac{1}{2})\lambda$ still holds when the amplitude of vibration is doubled
×	(3)	It may be neither constructive nor destructive interference occurs at P. It is because none of the conditions $\Delta x_P = n\lambda$ or $\Delta x_P = (n-\frac{1}{2})\lambda$ is hold.

20. A

Only amplitude (maximum displacement) and period (time) can be deduced directly from the displacement-time graph.

✓	(1)	Since $f = \dfrac{1}{T}$, the frequency of the wave can also be deduced.
×	(2)	
×	(3)	

21. A

If any two balls attract each other, that means they are positive charged, negatively charged and neutral respectively.

Suppose those three balls are denoted by X, Y and Z which are positive charged, negatively charged and neutral at the beginning respectively.

		charges carry by				*charges carry by*		
		ball X	ball Y	ball Z		ball X	ball Y	ball Z
At the beginning		$+q$	$-q$	0		$+q$	$-q$	0
Firstly	X touched Y	0	0	0	X touched Z	$+q/2$	$-q$	$+q/2$
Then	X touched Z	$\boldsymbol{0}$	$\boldsymbol{0}$	$\boldsymbol{0}$	X touched Y	$\boldsymbol{-q/4}$	$\boldsymbol{-q/4}$	$\boldsymbol{+q/2}$
		(1) statement				**(2) statement**		

		charges carry by				*charges carry by*		
		ball X	ball Y	ball Z		ball X	ball Y	ball Z
At the beginning		$+q$	$-q$	0		$+q$	$-q$	0
Firstly	Y touched X	0	0	0	Y touched Z	$+q$	$-q/2$	$-q/2$
Then	Y touched Z	$\boldsymbol{0}$	$\boldsymbol{0}$	$\boldsymbol{0}$	Y touched X	$\boldsymbol{+q/4}$	$\boldsymbol{+q/4}$	$\boldsymbol{-q/2}$
		(1) statement				**(2) statement**		

		charges carry by				*charges carry by*		
		ball X	ball Y	ball Z		ball X	ball Y	ball Z
At the beginning		$+q$	$-q$	0		$+q$	$-q$	0
Firstly	Z touched X	$+q/2$	$-q$	$+q/2$	Z touched Y	$+q$	$-q/2$	$-q/2$
Then	Z touched Y	$\boldsymbol{+q/2}$	$\boldsymbol{-q/4}$	$\boldsymbol{-q/4}$	Z touched X	$\boldsymbol{+q/4}$	$\boldsymbol{-q/2}$	$\boldsymbol{+q/4}$
		(2) statement				**(2) statement**		

22. D

(Suppose the electric field towards right be positive.)

At position W, $E_W = [\frac{1}{4\pi\varepsilon}\frac{6Q}{(3d)^2}] + [-\frac{1}{4\pi\varepsilon}\frac{2Q}{(7d)^2}] = \frac{23}{147}\frac{Q}{\pi\varepsilon d^2}$

At position X, $E_X = [-\frac{1}{4\pi\varepsilon}\frac{6Q}{(d)^2}] + [-\frac{1}{4\pi\varepsilon}\frac{2Q}{(3d)^2}] = -\frac{14}{9}\frac{Q}{\pi\varepsilon d^2}$

At position Y, $E_Y = [-\frac{1}{4\pi\varepsilon}\frac{6Q}{(2d)^2}] + [\frac{1}{4\pi\varepsilon}\frac{2Q}{(2d)^2}] = -\frac{1}{4}\frac{Q}{\pi\varepsilon d^2}$

At position Z, $E_Z = [-\frac{1}{4\pi\varepsilon}\frac{6Q}{(6d)^2}] + [\frac{1}{4\pi\varepsilon}\frac{2Q}{(2d)^2}] = \frac{1}{12}\frac{Q}{\pi\varepsilon d^2}$ which has the smallest magnitude.

23. C

When switch S is closed, $R_{XY} = (\frac{1}{100} + \frac{1}{R})^{-1} = 99\,\Omega$

When switch S is opened, $R'_{XY} = (\frac{1}{100} + \frac{1}{R+R})^{-1}$

$\because R'_{XY} = (\frac{1}{100} + \frac{1}{R+R})^{-1} > (\frac{1}{100} + \frac{1}{R})^{-1} = 99$ and $R'_{XY} = (\frac{1}{100} + \frac{1}{R+R})^{-1} < (\frac{1}{100})^{-1} = 100$

$\therefore 99 < R'_{XY} < 100$

24. A

For case B, the lighting device always turns on when S_1 is closed.

For case C, the lighting device always turns on either S_1 or S_2 is closed.

For case D, the lighting device always turns off either S_1 or S_2 is opened.

25. D

×	A	According to Fleming's **right** hand rule, rod PQ induced a current flow from Q to P when the rod move towards left initially. i.e. the induced current is in the direction $SRQP$ (anticlockwise).
×	B	According to Fleming's **left** hand rule, there is a leftwards included magnetic force acts on the rod RS when the current flow from S to R and B-field points into paper.
×	C	According to Lenz's law, there is a force acts on the rod PQ towards right to against the reason (moving to left).
✓	D	The rod PQ decelerates.

26. B

$$F_{net} = F_E \quad \Rightarrow \quad m\vec{a} = q\vec{E}$$

$$\Rightarrow \quad m\vec{a} = (-e)\vec{E}$$

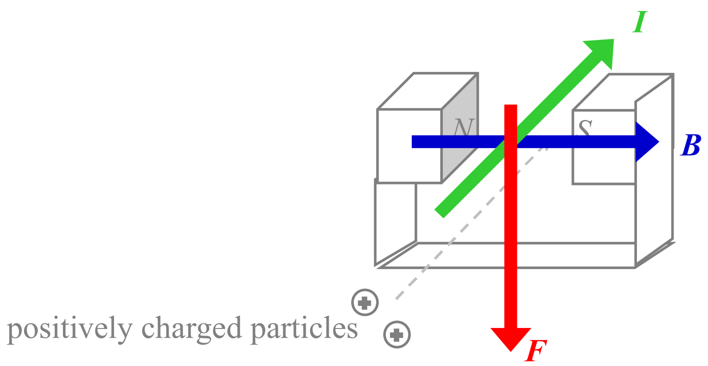
$$\Rightarrow \quad \vec{a} = -\frac{e}{m}\vec{E}$$

27. D

According the equation $R = \frac{\rho l}{A} = \frac{4\rho l}{\pi d^2}$,only resistance R is affected by the length and the diameter d but only resistitivty .ρ.

28. B

According to Fleming's left hand rule:



29. D

According to the Lenz's law, the induced current should flows anti-clockwisely to against the increasing of B-field when the ring when the ring is entering the magnetic field.

According to the Lenz's law, the induced current should flows clockwisely to against the decreasing of B-field when the ring when the ring is leaving the magnetic field.

30. B

$$V = \left(\frac{(\frac{1}{3}+\frac{1}{6})^{-1}}{4+(\frac{1}{3}+\frac{1}{6})^{-1}}\right)(12) = \underline{\underline{4\text{ V}}}$$

31. A

The (kinetic) energy of α-particles can be absorbed effectively (weak penetrating power).

32. B

$N = N_0 e^{-kt} \quad \Rightarrow \quad N = N_0 e^{-(0.06)(1\times 60)} = 0.0273 N_0$

33. D

$235 + 1 = 137 + 95 + k\times 1$

$\therefore\ k = 4$

Δm = (235.043 93u + 1.008 67u) – (136.907 09u + 94.929 30u + 4 × 1.008 67u)

= 0.18153u

= 0.18153 × 1.661×10^{-27} kg

≈ 3.015×10^{-28} kg

$E = mc^2 = (3.015 \times 10^{-28})(3\times 10^8)^2$

$= \underline{\underline{2.71\times 10^{-11}\text{ J}}}$

Paper I Section B

			Marks
1.	(a)	Energy supplied by the stove $= Pt$	
		$= 2300 \times 30 \times 60$	
		$= 4.14 \times 10^6$ J	1 M
		Energy absorbed by the water $= mc\Delta T + m_v l_v$	
		$= 4 \times 4200 \times (100 - 20) + (4 \times 30\%) \times (2.26 \times 10^6)$	
		$= 4.056 \times 10^6$ J	1 M
		According to conservation law of energy,	
		$C\Delta T + mc\Delta T + m_v l_v = Pt$	
		$C \times (100 - 20) + 4.056 \times 10^6 = 4.14 \times 10^6$	1 M
		$C = \underline{\underline{1050 \text{ J °C}^{-1}}}$	1 A
	(b)	The mass of the water evaporated is negligible.	1 A
	(c)	The body of the kettle is made of <u>metal</u>; therefore heat can be <u>conducted</u> from the stove to the water inside the kettle <u>effectively</u>.	1 A
		The <u>surface</u> of the kettle is <u>shinny</u>; therefore the <u>heat loss</u> from the kettle by <u>radiation</u> is <u>reduced</u>.	1 A
2.	(a)	By $pV = nRT$	1 M
		$\Delta n = \dfrac{p\Delta V}{RT} = \dfrac{100 \times 10^3 \times (200 - 100) \times 10^{-6}}{8.31 \times (273 + 25)} = \underline{\underline{4.04 \times 10^{-3} \text{ mol}}}$	1 A
	(b)	Suck air out of the box through tube X. (Or other reasonable answers)	1 A

Marks

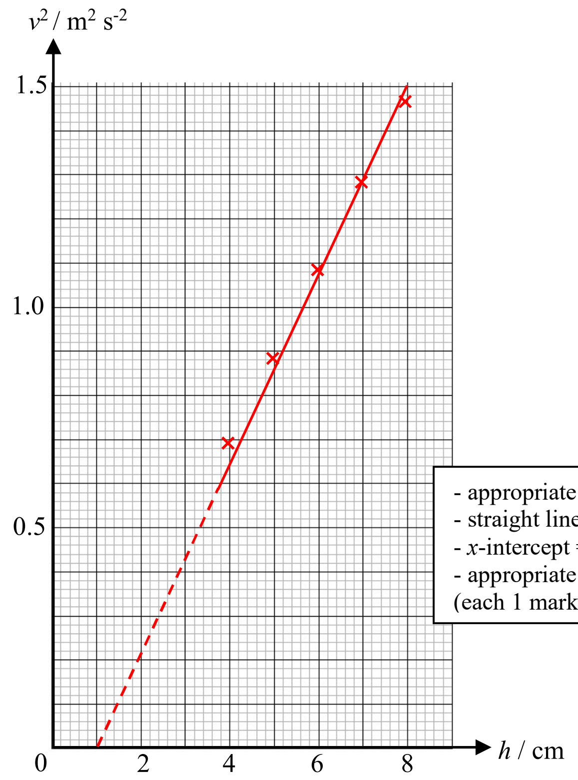
3. (a) $\Delta PE = \Delta KE$

$$mg(h-1) = \frac{1}{2}mv^2 - \frac{1}{2}m(0)^2$$ 1 M

$\therefore \quad v^2 = 2g(h-1)$ where $h \geq 1$ | without condition of h reduce 1 mark | 1 M + 1 A

(b) (i)

Height h /cm	4.0	5.0	6.0	7.0	8.0
Speed v / m s^{-1}	0.828	0.939	1.04	1.13	1.21
v^2 / m^2 s^{-2}	0.686	0.882	1.08	1.28	1.46



- appropriate axis with correct unit
- straight line
- x-intercept = 1
- appropriate data
(each 1 mark)

4 M

(ii) slope of the graph $= \frac{1.5-0}{8-1} = \underline{\underline{0.214}}$ (accept from 0.21 to 0.22) 1 A

According to the equation $v^2 = 2g(h-1)$, the slope of the graph equals to $2g$.

thus, $2g = \frac{1.5-0}{(8-1)\times 0.01}$

$\therefore \quad g = \underline{\underline{10.7 \text{ m s}^{-2}}}$ (accept from 10.5 to 11.0) 1 A

(c) air resistance / ball's rotation / other reasonable answers. 1 M

Marks

4. (a) $mgh = \frac{1}{2}mv^2 \quad \Rightarrow \quad v = \sqrt{2gh} = \sqrt{2 \times 9.81 \times 2}$ 1 M

$= \underline{\underline{6.26 \text{ m s}^{-1}}}$ 1 A

(b) $m_1u_1 + m_2u_2 = (m_1+m_2)v$

$70(6.26) + 35(0) = (70+35)v$ 1 M

$\therefore \ v = \underline{\underline{4.17 \text{ m s}^{-1}}}$ 1 A

(c) $mgh = \frac{1}{2}mv^2 \quad \Rightarrow \quad h = \frac{v^2}{2g} = \frac{(4.17)^2}{2(9.81)} = \underline{\underline{0.886 \text{ m}}}$

$\therefore$ No, they cannot come back to the pier. 1 M+1 A

(d) $mgh = \frac{1}{2}mv^2 \quad \Rightarrow \quad v' = \sqrt{2gh} = \sqrt{2 \times 9.81 \times 2} = \underline{6.26 \text{ m s}^{-1}}$

$m_1u'_1 + m_2u_2 = (m_1+m_2)v'$

$(70)u'_1 + 35(0) = (70+35)(6.26)$ 1 M

$\underline{u'_1 = 9.39 \text{ m s}^{-1}}$

$\Delta K.E. = \Delta P.E. \quad \Rightarrow \quad \frac{1}{2}mv^2 - \frac{1}{2}mu^2 = mgh$

$\frac{1}{2}m(9.39)^2 - \frac{1}{2}mu^2 = m(9.81)(2)$ 1 M

$\therefore \ u = \underline{\underline{7 \text{ m s}^{-1}}}$ 1 A

5. (a) Let T be the tension of the elastic cord, and R_H and R_V be the horizontal and vertical components of the reaction force acting on the bar at X.

$XO = 1.2 - 0.8 = 0.4$ m

$XQ = 1.2 \times 2 - 0.8 = 1.6$ m

Take moment about X. In equilibrium,

$T \sin 30° \times 0.8 = 50 \times 9.81 \times 0.4 + 2000 \times 1.6$ 1 M

$T = 8490$ N 1 A

(b) The magnitude of the tension of the elastic cord is 8490 N.

Along the vertical direction:

$R_V = T \sin 30° + 50 \times 9.81 + 2000 = 6740$ N 1M

Along the horizontal direction:

$R_H = T \cos 30° = 7350$ N 1M

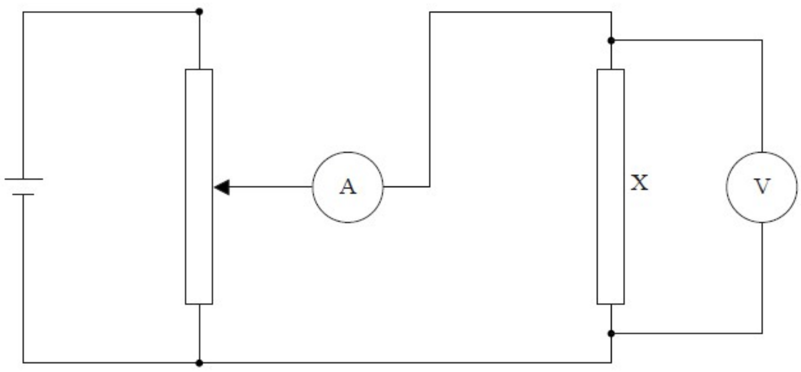
Magnitude of the reaction force acting on the bar at $X = \sqrt{R_V{}^2 + R_H{}^2}$

$= \sqrt{6740^2 + 7350^2}$

$= 9970$ N 1A

Marks

6. (a) 3 M



(b) $V = IR$

$2 = (2.4)R$ 1 M

$R = \underline{\underline{0.833\ \Omega}}$ 1 A

(c) $\varepsilon = I(R+1)$ 1 M

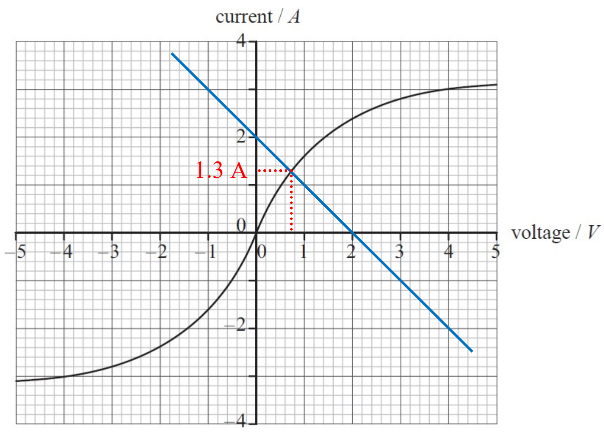
$\varepsilon = IR+I$

$\varepsilon - I = V$

$I = -V + \varepsilon$

$I = -V + 2$

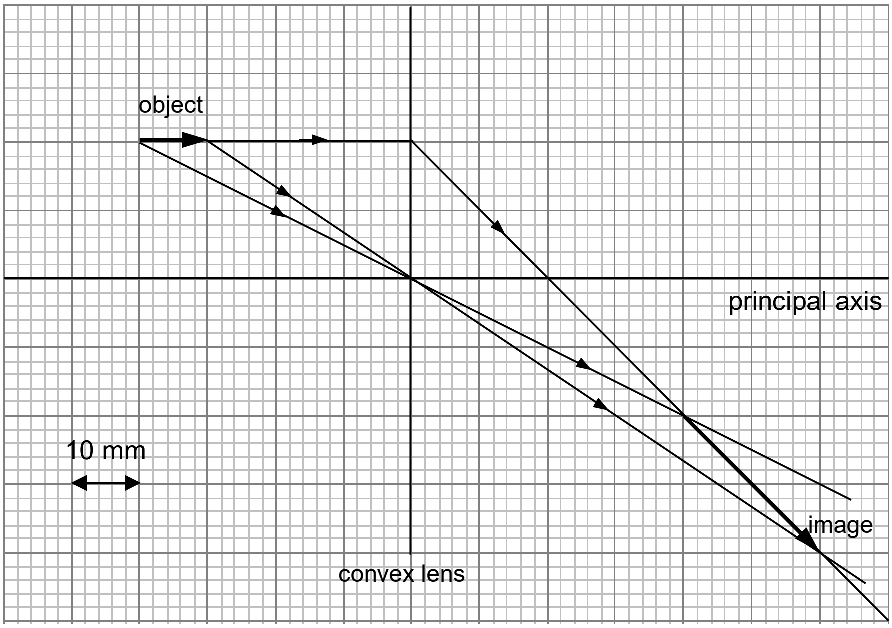
(plot a straight line according to the equation $I = -V + 2$, on the current-voltage characteristics graph)` 1 M



$I = \underline{\underline{1.3\text{ A}}}$ (1.2-1.4 A is accepted) 1 A

Marks

7. (a)



3 correct light rays | 3×1 A
(Withhold 1 mark for dotted lines or with wrong / no direction)
Correct image | 1 A

(b) $\frac{1}{u}+\frac{1}{v}=\frac{1}{f}$ and let $d=u+v$

$$\frac{1}{u}+\frac{1}{d-u}=\frac{1}{f}$$

$$\frac{(d-u)+u}{u(d-u)}=\frac{1}{f}$$

$$df=u(d-u)$$

$$u^2-ud+df=0$$ 1 M

$$u^2-2u(\frac{d}{2})+(\frac{d}{2})^2-(\frac{d}{2})^2-df=0$$

$$(u-\frac{d}{2})^2=(\frac{d}{2})^2-df$$ 1 M

$$\because (u-\frac{d}{2})^2 \geq 0 \quad \Rightarrow \quad (\frac{d}{2})^2-df \geq 0$$

$$\frac{d^2}{4} \geq df$$

$$d \geq 4f$$

$$u+v \geq 4f$$ 1 M

Marks

8. (a) $n_a \sin\theta_a = n_g \sin\theta_g \quad \Rightarrow \quad (1)\sin 60° = (1.52)\sin r$ 1 M

$\Rightarrow \quad r = \sin^{-1}(\frac{\sin 60°}{1.52}) = 34.73°$

$\theta = 90° - r = 55.3°$ 1 M

Since the critical angle $C = \sin^{-1}\frac{1}{1.52} = 41.1° < \theta$, total internal reflection occurs at A. 1 M

Therefore, the light ray **<u>will not emerge</u>** from A. 1 A

(b)

$$\begin{cases} n\sin r = (1)\sin 60° \\ n\sin\theta = (1)\sin 90° \end{cases} \Rightarrow \begin{cases} n = \dfrac{\sin 60°}{\sin r} \\ n = \dfrac{\sin 90°}{\sin(90° - r)} \end{cases} \Rightarrow \frac{\sin 60°}{\sin r} = \frac{\sin 90°}{\sin(90° - r)}$$

$\Rightarrow \sin 60° = \tan r \quad \Rightarrow \quad r = 40.9°$ 1 M

$\therefore \quad n = \frac{\sin 60°}{\sin 40.9°} = \underline{\underline{1.32}}$ 1 A

9. (a) The electric field points <u>upwards</u>. 1 M

$E = \frac{V}{d} = \frac{4.68\times10^3}{0.5\times10^{-2}} = \underline{\underline{936000 \text{ N C}^{-1}}}$ 1 A

(b) The magnetic force points <u>downwards</u>. 1 M

$F_B = F_E = qE = (3.2\times10^{-19})(936000) = \underline{\underline{3.00\times10^{-13} \text{ N}}}$ 1 A

(c) $F_B = qvB \sin\theta$

$3.00\times10^{-13} = (3.2\times10^{-19})v(1.8) \sin 90°$ 1 M

$\therefore \; v = \underline{\underline{5.20\times10^5 \text{ m s}^{-1}}}$ 1 A

(d) $F_C = F_B \quad \Rightarrow \quad \frac{mv^2}{r} = qvB$

$\Rightarrow \quad r = \frac{mv}{Bq} = \frac{(6.64\times10^{-27})(5.2\times10^5)}{(2)(3.2\times10^{-19})} = 0.005395 \text{ m}$ 1 M

$\therefore \; d = 2r = \underline{0.0108 \text{ m}}$ 1 A

(e) (i) There are two forces, electrostatic force F_E and the induced magnetic force F_B, which are in opposite direction acts on the electron.

$F_E = F_B \quad \Leftrightarrow \quad qE = qvB \quad \Leftrightarrow \quad v = \frac{E}{B}$

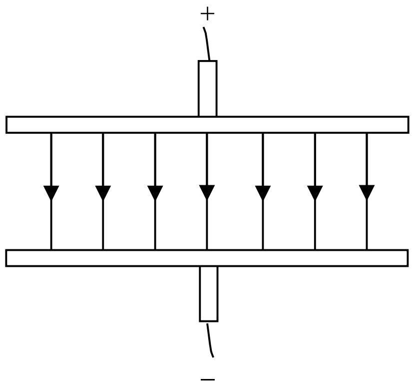
When an electron is projected to the selector at the speed in (c), that means <u>net force on it is zero</u> since <u>F_E and F_B equals and in opposite</u>. So, the electron can pass without deflection. 1 M+1 M

(ii) The radius of circular path / the rotating direction / period of the circular motion (any two) 1 M+1 M

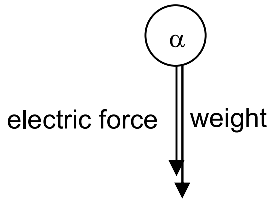
Marks

10. (a) (i) (Parallel and evenly spaced field lines) 1 A

(Correct direction) 1 A



(ii) 1 A+1 A



(2 correct labelled forces)

(iii) The <u>polarities</u> of the parallel plates are <u>reversed</u>. 1 A

(b) (i) Electric force = weight

$$Eq = mg$$ 1 M

$$E = \frac{mg}{q}$$

$$= \frac{10^{-27} \times 9.81}{2 \times 1.60 \times 10^{-19}}$$

$$= 3.066 \times 10^{-8}\ \text{N C}^{-1}$$

$$= 3.07 \times 10^{-8}\ \text{N C}^{-1}$$ 1 A

The electric field strength needed is about 3.07×10^{-8} N C^{-1}.

(ii) By $E = \dfrac{V}{d}$

$V = Ed = 3.066 \times 10^{-8} \times 0.005 = 1.53 \times 10^{-10}$ V 1 M +1 A

The potential difference between the plates required is about 1.53×10^{-10} V.

(iii) The <u>EHT</u> power supply is <u>not suitable</u> for the experiment 1 A

since it is <u>unable to provide</u> such a <u>small voltage</u> output. 1 A

Marks

11. (a) Consider the atomic numbers

$92 + 0 = 36 + x + 2 \times 0$

$x = 56$ 1 A

It denotes the atomic number (or proton number) of Ba. 1 A

(b) The neutrons released in the nuclear reaction continue splitting other ${}^{235}_{92}\text{U}$ nuclei. 1 A

(c) Mass difference in the nuclear reaction

$= (235.0439 + 1.0087) - (89.9195 + 143.9229 + 2 \times 1.0087)$

$= 0.1928$ u 1M

Total energy output $= \Delta mc^2 \times (3600 \times 24)$

$$= \left(2 \times 10^{-5} \times \frac{0.1928}{235.0439}\right) \times (3.00 \times 10^8)^2 \times (3600 \times 24)$$ 1M

$= 1.28 \times 10^{14}$ J 1A

Paper II

Section A: Astronomy and Space Science

1.	2.	3.	4.	5.	6.	7.	8.
D	B	B	B	B	B	C	B

Marks

1. (a) About 7000 K — 1 A

(b) $d = \dfrac{1}{p} = \dfrac{1}{(\frac{6.00\times 10^{-3}}{2})}$ — 1 M

$\Rightarrow \quad d = \underline{\underline{333 \text{ pc}}}$ — 1 A

(c) (i) By Doppler shift $\dfrac{\Delta\lambda}{\lambda_0} = \dfrac{v_r}{c}$ — 1 M

By comparing the spectrum of the object with the spectrum of a stationary object, the radial velocity of Gemini ζ can be determined. — 1 M +1 A

(ii) $v_r = \dfrac{2\pi r}{T} \quad \Rightarrow \quad 620 = \dfrac{2\pi r}{(233\times 86400)} \quad \Rightarrow \quad r = \underline{\underline{1.99\times 10^9 \text{ m}}}$ — 1 A

The range of radius of the star $R = 60R_\odot \pm r$

$= 60\times 695500\times 10^3 \pm 1.99\times 10^9$

$= (4.173\times 10^{10} \pm 1.99\times 10^9)$ m $\qquad = (60 \pm 2.86)\ R_\odot$

i.e. $\underline{\underline{3.974\times 10^{10} \text{ m} < R < 4.372\times 10^{10} \text{ m}}}$ $\qquad$ or $57.1R_\odot < R < 62.9R_\odot$ — 1 A

By Stefan's law, $L = 4\pi\sigma R^2 T^4$

Minimum luminosity $= 4\pi(5.67\times 10^{-8})(3.974\times 10^{10})^2 (7000)^4$

$= 2.40\times 10^{30}$ J s^{-1} — 1 A

Maximum luminosity $= 4\pi(5.67\times 10^{-8})(4.372\times 10^{10})^2 (7000)^4$

$= 3.27\times 10^{30}$ J s^{-1} — 1 A

i.e. $\underline{\underline{2.40\times 10^{30} \text{ J s}^{-1} < L < 3.27\times 10^{30} \text{ J s}^{-1}}}$

Section B: Atomic world

1.	2.	3.	4.	5.	6.	7.	8.
A	B	D	C	A	B	D	D

Marks

2. (a) Transmission electron microscope — 1 M

(b) An electron gun consists of a cathode and accelerating anode. — 1 M

(c) After the electrons released from the electron gun and hits the specimen, some electrons are scattered and some others will pass through the specimen. The amount of electrons passed through is affected by the density of the specimen. Hence the amount of electron passed through can reveal the details of the specimen. — 1 M

The electron beam is deflected by magnetic objective lens and magnetic projecting lens after passing through the specimen. — 1 M

Finally, the electron beam is focused on the screen to form an image. — 1 M

(d) For an transmission electron microscope to resolve a length of 0.25 nm, the wavelength of an electron $\lambda \approx 2.5 \times 10^{-10}$ m. — 1 M

$$p = \frac{h}{\lambda} = \frac{6.63\times10^{-34}}{2.5\times10^{-10}} = 2.65 \times 10^{-24}\ \text{kg m s}^{-1}$$ — 1 M

Kinetic energy gained by electrons is provided from the potential difference between the cathode and anode. Hence,

$$eV = \frac{1}{2}mv^2 \quad \Rightarrow \quad V = \frac{p^2}{2me} = \frac{(2.65\times10^{-24})^2}{2(9.11\times10^{-31})(1.60\times10^{-19})}$$ — 1 M

$$= \underline{\underline{24.1\ \text{V}}}$$ — 1 A

(e) Increase the potential difference between cathode and anode. — 1 M

Section C: Energy and Use of energy

1.	2.	3.	4.	5.	6.	7.	8.
A	D	C	B	C	C	D	B

			Marks
3.	(a)	A building envelope consists of walls and windows.	1 M + 1M
		The building gains heat through the walls by conduction	1 M
		The building gains heat through the windows by radiation of sunlight.	1 M
	(b)	$\frac{Q_C}{t}=\frac{\kappa A\Delta T}{d}=\frac{(3)(530\times 4\times \frac{31}{31+13})(42-24)}{1}=80656\text{ W}$	1 M
		$\frac{P_C}{A}=\frac{80656}{530\times 4\times \frac{31}{31+13}}=\underline{\underline{54\text{ W m}^{-2}}}$	1 A
		or $\frac{P_C}{A}=\frac{(\frac{Q_C}{t})}{A}=\frac{(\frac{\kappa A\Delta T}{d})}{A}=\frac{\kappa\Delta T}{d}=\frac{(3)(42-24)}{1}=\underline{\underline{54\text{ W m}^{-2}}}$	1 M + 1 A
	(c)	$\frac{Q_r}{t}=(530\times\frac{13}{31+13}\times 4)(30)=\underline{\underline{18800\text{ W}}}$	1 M + 1 A
	(d)	$\text{OTTV}=\frac{80565+18800+4080}{530\times 4+650}=\underline{\underline{37.4\text{ W m}^{-2}}}$	1 M + 1 A

Section D: Medical Physics

1.	2.	3.	4.	5.	6.	7.	8.
A	B	B	C	A	B	A	C

Marks

4. (a)

$$\text{Half-value thickness} = \frac{\ln 2}{\mu}$$

$$= \frac{\ln 2}{4.0}$$ 1 M

$= \underline{\underline{0.173 \text{ cm}}}$ 1 A

(b) (i) ${}^{99m}_{43}\text{Tc} \rightarrow {}^{99}_{43}\text{Tc} + \gamma$ 1 A

(ii) It emits γ radiation only, which <u>causes very little amount of cellular damage</u> 1 A
and <u>can emerge from inside</u> the patient to be detectable externally. 1 A
Also, the decay product (technetium-99) is stable as it has a <u>very long half-life</u>. 1 A

(iii) By $\frac{1}{t_{eff}} = \frac{1}{t_{phy}} + \frac{1}{t_{bio}}$,

$$t_{eff} = \left(\frac{1}{t_{phy}} + \frac{1}{t_{bio}}\right)^{-1} = \left(\frac{1}{6} + \frac{1}{24}\right)^{-1} = 4.8 \text{ hours}$$ 1 M

24 hours = 5 × 4.8 hours (= 5 half-lives) 1 M

Activity after 24 hours $= 4 \times 10^{8} \times \left(\frac{1}{2}\right)^{5} = 1.25 \times 10^{7}$ Bq 1A

(c) Radionuclide imaging 1A