2021-DSE
物理

卷一 甲部

香 港 考 試 及 評 核 局

2 0 2 1 年 香 港 中 學 文 憑 考 試

物理 試卷一

本試卷必須用中文作答

兩小時三十分鐘完卷 (上午八時三十分至上午十一時)

考生須知

(一) 本卷分**甲**、**乙兩部**。考生宜於約 50 分鐘內完成甲部。

(二) 甲部為多項選擇題，見於本試卷中；乙部的試題另見於試題答題簿 **B** 內。

(三) 甲部的答案須填畫在多項選擇題的答題紙上，而乙部的答案則須寫在試題答題簿所預留的空位內。**考試完畢，甲部之答題紙與乙部之試題答題簿須分別繳交**。

(四) 本試卷的附圖**未必**依比例繪成。

(五) 試卷最後兩頁附有本科常用的數據、公式和關係式以供參考。

甲部考生須知（多項選擇題）

(一) 細讀答題紙上的指示。宣布開考後，考生須首先於適當位置貼上電腦條碼及填上各項所需資料。宣布停筆後，考生不會獲得額外時間貼上電腦條碼。

(二) 試場主任宣布開卷後，考生須檢查試題有否缺漏，最後一題之後應有「**甲部完**」字樣。

(三) 各題佔分相等。

(四) **本試卷全部試題均須回答**。為便於修正答案，考生宜用 HB 鉛筆把答案填畫在答題紙上。錯誤答案可用膠擦將筆痕徹底擦去。考生須清楚填畫答案，否則會因答案未能被辨認而失分。

(五) 每題只可填畫**一個**答案，若填畫多個答案，則該題**不給分**。

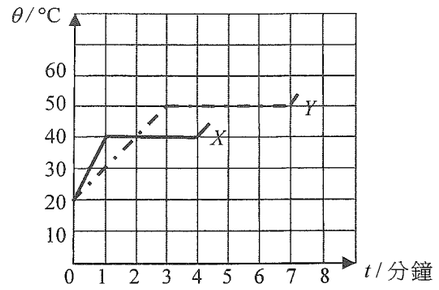
(六) 答案錯誤，不另扣分。

考試結束前不可
將試卷攜離試場

甲部

本部共有 33 題。標示有 * 的題目涉及延展部分的知識。

1. 質量相等的固體物質 X 和 Y，分別以功率 $2P$ 和 P 的發熱器加熱。線圖顯示每一物質的溫度 θ 如何跟加熱時間 t 變化。



X 和 Y 的熔解比潛熱之比是多少？

A. 3 : 2
B. 3 : 4
C. 4 : 3
D. 2 : 3

2. 金屬方塊 X 和 Y 的大小和形狀相同，而 X 的溫度比 Y 高。下列哪項敍述必定正確？

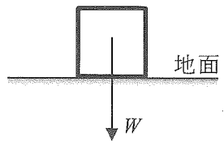
(1) 如果兩者有熱接觸，能量會從 X 流往 Y。
(2) X 相比於 Y 是較佳的導熱體。
(3) X 的總內能較 Y 的高。

A. 只有 (1)
B. 只有 (3)
C. 只有 (1) 和 (2)
D. 只有 (2) 和 (3)

*3. 就一理想氣體而言，分子運動論導出 $pV = \frac{1}{3}Nm\overline{c^2}$。以下哪個物理量可用 $\frac{3p}{\overline{c^2}}$ 表出？

A. 該氣體的總質量
B. 一摩爾氣體的體積
C. 該氣體的密度
D. 每單位體積內氣體分子的數目

4. 一重量為 W 的方塊靜止於水平地面上，如圖所示。



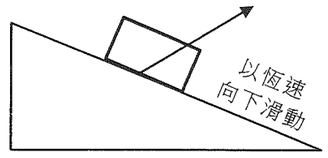
地面作用在方塊的力為 R。下列哪項敍述正確？

(1) R 和 W 方向相反。
(2) R 和 W 量值相等。
(3) R 和 W 是一對作用-反作用力。

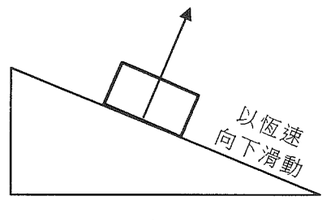
A. 只有 (1)
B. 只有 (1) 和 (2)
C. 只有 (2) 和 (3)
D. (1)、(2) 和 (3)

5. 一方塊沿一粗糙斜面以恆速向下滑動，如圖所示。哪一箭矢顯示**斜面對方塊所施合力**的方向？空氣阻力可忽略不計。

A.



B.



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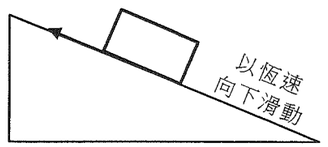
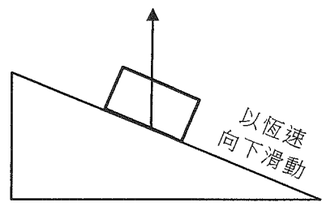
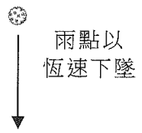


D.



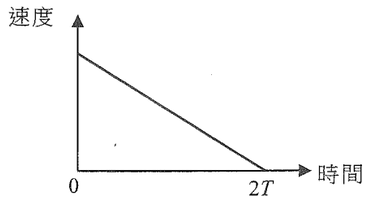
6. 對於以恆定終端速度下墜的雨點而言，以下哪項敍述正確？



A. 重力沒有對雨點作功。
B. 雨點下墜時，它的重力勢能損失全部轉換為動能增加。
C. 雨點唯一所受的力是其重量。
D. 沒有淨力作用在雨點上。

續 後 頁

7. 在時間 $t = 0$，以某初速將一小球沿光滑斜面向上彈射。它運動一段距離 L 並經過時間 $2T$ 之後瞬時靜止。相應的速度-時間線圖如下。



該球從 $t = 0$ 至 $t = T$ 運動了多少距離？

A. $\frac{1}{4}L$
B. $\frac{1}{2}L$
C. $\frac{3}{4}L$
D. $\frac{4}{5}L$

8. 一靜止的鈾原子核 $^{238}_{92}\mathrm{U}$ 衰變而成一釷原子核 $^{234}_{90}\mathrm{Th}$ 以及一 α 粒子 $^{4}_{2}\mathrm{He}$。

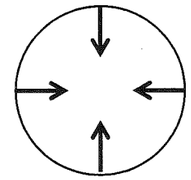
$$^{238}_{92}\mathrm{U} \longrightarrow {}^{234}_{90}\mathrm{Th} + {}^{4}_{2}\mathrm{He}$$

以下哪項正確描述衰變剛發生後 $^{234}_{90}\mathrm{Th}$ 原子核及 α 粒子的情況？

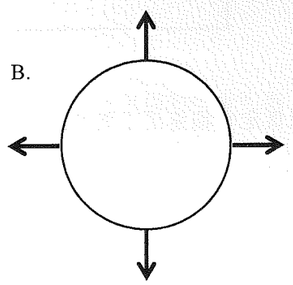
	動量的量值 p	動能 KE
A.	$p(\mathrm{Th}) = p(\alpha)$	$\mathrm{KE(Th)} < \mathrm{KE}(\alpha)$
B.	$p(\mathrm{Th}) > p(\alpha)$	$\mathrm{KE(Th)} > \mathrm{KE}(\alpha)$
C.	$p(\mathrm{Th}) = p(\alpha)$	$\mathrm{KE(Th)} > \mathrm{KE}(\alpha)$
D.	$p(\mathrm{Th}) = p(\alpha)$	$\mathrm{KE(Th)} = \mathrm{KE}(\alpha)$

*9. 一粒子以勻速率沿一水平圓形順時針運動(俯視)。以下哪幅俯視圖正確顯示該粒子在不同位置時所受的淨力？

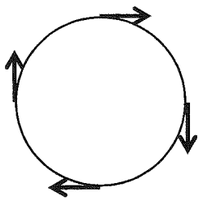
A.



B.



C.



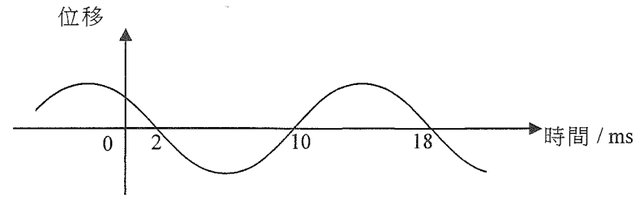
D.

10. 以下哪項可藉機械波沿傳播方向從一處傳遞至另一處？

(1) 質量
(2) 動量
(3) 能量

A. 只有 (1) 和 (2)
B. 只有 (1) 和 (3)
C. 只有 (2) 和 (3)
D. (1)、(2) 和 (3)

11.



在一行波上一粒子的位移-時間線圖如圖所示。求波的頻率。

A. 55.6 Hz
B. 62.5 Hz
C. 111 Hz
D. 125 Hz

12. 地震以波的形式傳播。地震震央會產生縱波 (P-波) 和橫波 (S-波)，並分別以速率 9.6 km s^{-1} 和 6.4 km s^{-1} 在地殼傳播。於某次地震，一監測站在 7:02 a.m. 錄得 P-波脈衝到達，而 S-波脈衝則於 2 分鐘後在 7:04 a.m. 到達。估算這次地震發生的時間。

A. 6:53 a.m.
B. 6:56 a.m.
C. 6:58 a.m.
D. 6:59 a.m.

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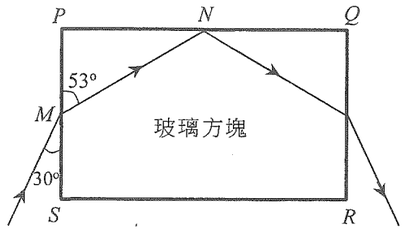
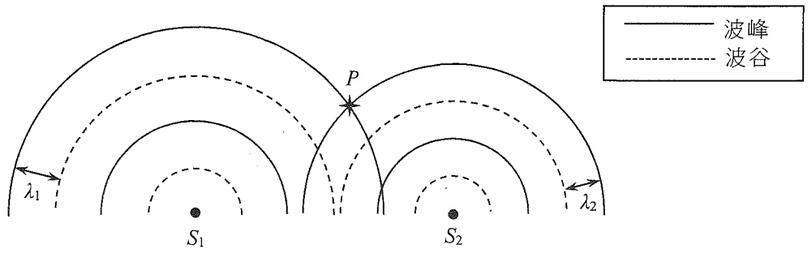
13.



圖示一長方形玻璃方塊 *PQRS* 的截面。一光線於面 *PS* 的 *M* 點從空氣入射，而折射線射向面 *PQ* 的 *N* 點。求玻璃-空氣分界面的臨界角。

A. 37°
B. 44°
C. 53°
D. 60°

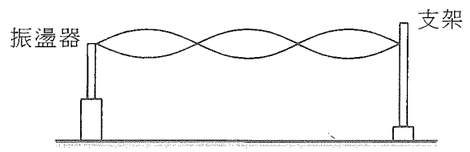
14. 在一水波槽內，兩個振動器 S_1 和 S_2 分別產生波長為 λ_1 和 λ_2 ($\lambda_1 > \lambda_2$) 的圓形水波。圖示於某一刻在水面上傳播的兩組圓形水波。



以下哪項敍述是正確的？

A. 在 *P* 的粒子總是處於波峰位置。
B. 兩波在 *P* 總是相互加強，並造成較大的振幅。
C. 因 $\lambda_1 \neq \lambda_2$，疊加原理不適用於 *P*。
D. 疊加原理適用於 *P*，但兩波於該處並非總是相互加強。

15. 在下面的裝置中，調校振盪器的頻率 *f* 可使彈性繩上出現不同的駐波圖樣。

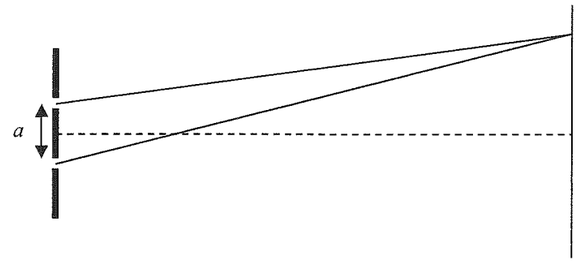


當 *f* 增加，以下哪些敍述正確？

(1) 波腹的數目增加。
(2) 繩上波動的速率增加。
(3) 繩在空氣中產生波動的頻率增加。

A. 只有 (1) 和 (2)
B. 只有 (1) 和 (3)
C. 只有 (2) 和 (3)
D. (1)、(2) 和 (3)

16. 在一個使用單色光的楊氏雙縫實驗中，如果雙縫的間距 *a* 減少，干涉圖樣會怎樣改變？



(1) 圖樣會更光亮。
(2) 可觀察到的條紋數目會增加。
(3) 圖樣的條紋間距會增大。

A. 只有 (1)
B. 只有 (3)
C. 只有 (1) 和 (2)
D. 只有 (2) 和 (3)

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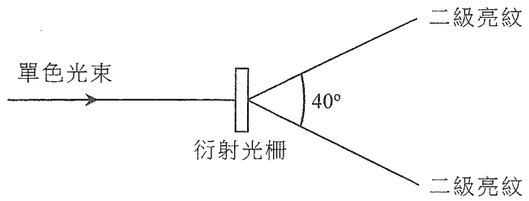
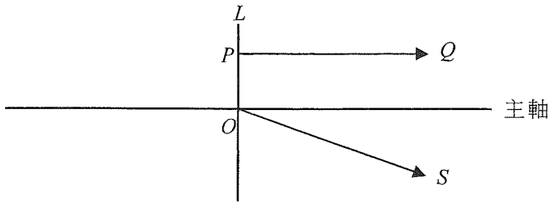
*17.



當一單色光束正入射一塊每 mm 有 300 線的衍射光柵，會形成一亮紋圖樣。兩條二級亮紋的夾角為 40°。求光的頻率。

A. 1.4×10^{14} Hz
B. 2.6×10^{14} Hz
C. 2.8×10^{14} Hz
D. 5.3×10^{14} Hz

18. 在下圖中，*PQ* 和 *OS* 是從透鏡 *L* 折射出的光線。這兩光線皆源自位於 *L* 左方的一個點物體。



以下哪項推斷正確？

(1) 該物體的像必定是虛像。
(2) 該物體必定在包含 *OS* 的直線上。
(3) *L* 必定是凹透鏡。

A. 只有 (1)
B. 只有 (3)
C. 只有 (1) 和 (2)
D. 只有 (2) 和 (3)

19. X 射線和微波的典型波長之比為 $10^n : 1$。*n* 的值可為

A. −10。
B. −4。
C. +4。
D. +10。

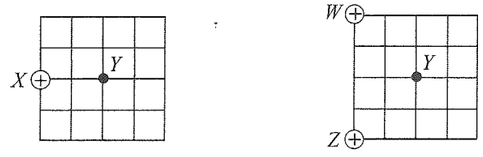
20. 潛艇是用超聲波來偵測海中的障礙物，而不是微波。這是由於

A. 超聲波的波長較微波的短。
B. 超聲波較微波在海中傳播得快。
C. 微波容易被海水吸收。
D. 微波在海中衍射得太多。

21. 三個相同的孤立金屬球 *X*、*Y* 和 *Z* 分別帶電荷 $+2Q$、$-4Q$ 和 $+5Q$。先讓 *Y* 跟 *X* 接觸，然後將 *Y* 移往接觸 *Z*。當 *Y* 和 *Z* 分開，求各球所帶的電荷。

	X	*Y*	*Z*
A.	0	$+1.5Q$	$+1.5Q$
B.	$-Q$	$+0.5Q$	$+0.5Q$
C.	$+Q$	$+Q$	$+Q$
D.	$-Q$	$+2Q$	$+2Q$

*22. 當一點電荷 $+Q$ 如圖所示置於 *X*，在 *Y* 的電場強度為 E_0。

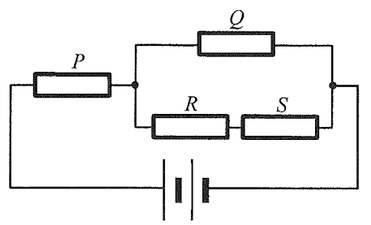


如果於 *W* 和 *Z* 分別放置一點電荷 $+Q$，在 *Y* 的電場強度會是多少？

註：$\sin 45° = \cos 45° = \frac{\sqrt{2}}{2}$

A. $\frac{\sqrt{2}}{2} E_0$
B. E_0
C. $\sqrt{2}\, E_0$
D. $2\, E_0$

23. 四個相同的電阻器 *P*、*Q*、*R* 和 *S* 連接一內阻可忽略的電池組，如圖所示。



如果 *R* 耗散 1 W 的功率，求電池組的總輸出功率。

A. 11 W
B. 15 W
C. 19 W
D. 21 W

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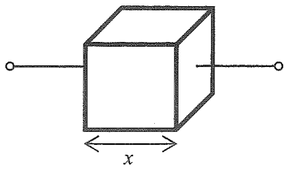
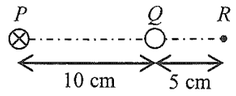
24. 圖示的金屬正方體邊長為 x。它任何相對的兩面之間的電阻 R 跟 x 的關係為何？



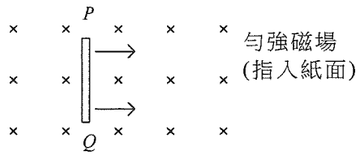
A. $R \propto \frac{1}{x}$
B. $R \propto x$
C. $R \propto x^2$
D. $R \propto \frac{1}{x^2}$

25. 下圖中的 PQR 為一直線，而 $PQ = 10$ cm 和 $QR = 5$ cm。載電流 0.3 A (方向為指入紙面) 的一條長直導線放於 P。當另一載電流 I 的長直導線放於 Q，在 R 的合磁場變為零。推斷 I 的方向和量值。



	***I* 的方向**	***I* 的量值**
A.	指入紙面	0.1 A
B.	指入紙面	0.9 A
C.	指出紙面	0.1 A
D.	指出紙面	0.9 A

26. 如圖所示，當一銅棒 PQ 以恆速度在一勻強磁場內運動，棒的兩端會感生一電動勢。

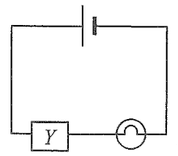


以下哪項敍述正確？

(1) 感生電動勢的量值取決於棒的長度。
(2) 棒 PQ 猶如一電池般提供一電動勢，而 P 為其正極。
(3) 有一力作用於棒並跟其運動對抗。

A. 只有 (1)
B. 只有 (3)
C. 只有 (1) 和 (2)
D. 只有 (2) 和 (3)

27. 一燈泡串聯連接一裝置 Y 和一電池，如圖所示。假設電池的內阻可忽略，而其電動勢保持不變。

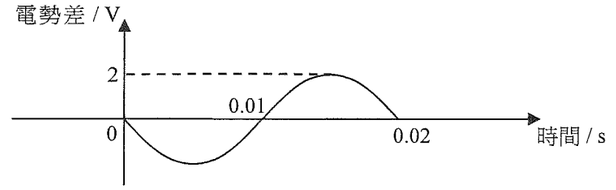


現觀察到燈泡的亮度隨時間下降。以下哪些推斷必定正確？

(1) 通過 Y 的電流隨時間減少。
(2) 跨 Y 的電壓隨時間下降。
(3) 電池所提供的功率隨時間減少。

A. 只有 (1) 和 (2)
B. 只有 (1) 和 (3)
C. 只有 (2) 和 (3)
D. (1)、(2) 和 (3)

*28. 一正弦交流電勢差施於一 10 Ω 電阻器的兩端，其波形如線圖所示。

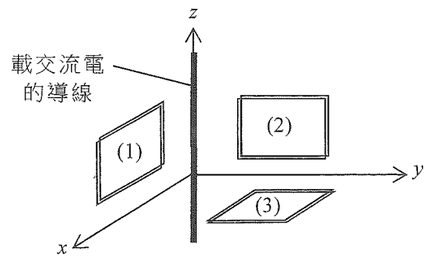


求該 10 Ω 電阻器上的方均根電流及它所耗的平均功率。

	方均根電流 / A	平均功率 / W
A.	0.14	0.2
B.	0.14	0.4
C.	0.2	0.2
D.	0.2	0.4

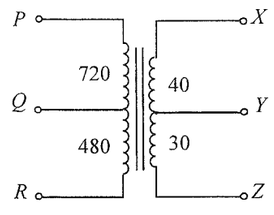
續 後 頁

29. 圖示一載交流電的導線沿 z 軸方向擺放，並於附近放置三個互相垂直的線圈 (1)、(2) 和 (3)。哪個線圈會有電動勢感生？



A. 只有 (1)
B. 只有 (3)
C. 只有 (1) 和 (2)
D. 只有 (2) 和 (3)

*30.



上圖顯示一複點分接的變壓器。各「分接點」之間的匝數如圖上所標示。哪一接駁適用於把電壓從 240 V 降壓至 6 V？

	原線圈	**副線圈**
A.	*PQ*	*XY*
B.	*PQ*	*YZ*
C.	*PR*	*XY*
D.	*PR*	*YZ*

31. 一個鈈-239 ($^{239}_{94}\mathrm{Pu}$) 放射性核素經過一系列的 α 和 β 衰變後，變成一穩定的鉛-207 同位素 ($^{207}_{82}\mathrm{Pb}$)。求在這過程中 β 衰變的數目。

A. 3
B. 4
C. 5
D. 6

32. 一個放射性樣本的放射強度量得為 18 MBq。該樣本在 3 個半衰期之前的放射強度是多少？

A. 6 MBq
B. 54 MBq
C. 72 MBq
D. 144 MBq

33. 以下哪項可以含有致電離輻射源？

(1) 海水
(2) 一岩石樣本
(3) 人體

A. 只有 (1)
B. 只有 (2)
C. 只有 (2) 和 (3)
D. (1)、(2) 和 (3)

甲部完

數據、公式和關係式

數據

摩爾氣體常數	$R = 8.31\ \text{J mol}^{-1}\ \text{K}^{-1}$
阿佛加德羅常數	$N_A = 6.02 \times 10^{23}\ \text{mol}^{-1}$
重力加速度	$g = 9.81\ \text{m s}^{-2}$ (接近地球)
萬有引力常數	$G = 6.67 \times 10^{-11}\ \text{N m}^2\ \text{kg}^{-2}$
在真空中光的速率	$c = 3.00 \times 10^8\ \text{m s}^{-1}$
電子電荷	$q_e = 1.60 \times 10^{-19}\ \text{C}$
電子靜止質量	$m_e = 9.11 \times 10^{-31}\ \text{kg}$
真空電容率	$\varepsilon_0 = 8.85 \times 10^{-12}\ \text{C}^2\ \text{N}^{-1}\ \text{m}^{-2}$
真空磁導率	$\mu_0 = 4\pi \times 10^{-7}\ \text{H m}^{-1}$
原子質量單位	$\text{u} = 1.661 \times 10^{-27}\ \text{kg}$ (1 u 相當於 931 MeV)
天文單位	$\text{AU} = 1.50 \times 10^{11}\ \text{m}$
光年	$\text{ly} = 9.46 \times 10^{15}\ \text{m}$
秒差距	$\text{pc} = 3.09 \times 10^{16}\ \text{m} = 3.26\ \text{ly} = 206265\ \text{AU}$
斯特藩常數	$\sigma = 5.67 \times 10^{-8}\ \text{W m}^{-2}\ \text{K}^{-4}$
普朗克常數	$h = 6.63 \times 10^{-34}\ \text{J s}$

直線運動

勻加速運動：

$$v = u + at$$
$$s = ut + \frac{1}{2}at^2$$
$$v^2 = u^2 + 2as$$

數學

直線方程	$y = mx + c$
弧長	$= r\theta$
柱體表面面積	$= 2\pi rh + 2\pi r^2$
柱體體積	$= \pi r^2 h$
球體表面面積	$= 4\pi r^2$
球體體積	$= \frac{4}{3}\pi r^3$
細小角度	$\sin\theta \approx \tan\theta \approx \theta$ (角度以 radians 表達)

天文學和航天科學

$U = -\frac{GMm}{r}$	引力勢能
$P = \sigma AT^4$	斯特藩定律
$\left\|\frac{\Delta f}{f_0}\right\| \approx \frac{v}{c} \approx \left\|\frac{\Delta\lambda}{\lambda_0}\right\|$	多普勒效應

原子世界

$\frac{1}{2}m_e {v_{max}}^2 = hf - \phi$	愛恩斯坦光電方程
$E_n = -\frac{1}{n^2}\left\{\frac{m_e q_e^4}{8h^2\varepsilon_0^2}\right\} = -\frac{13.6}{n^2}\ \text{eV}$	氫原子能級方程
$\lambda = \frac{h}{p} = \frac{h}{mv}$	德布羅意公式
$\theta \approx \frac{1.22\lambda}{d}$	瑞利判據 (解像能力)

能量和能源的使用

$E = \frac{\Phi}{A}$	照明度
$\frac{Q}{t} = \kappa\frac{A(T_H - T_C)}{d}$	傳導中能量的傳遞率
$U = \frac{\kappa}{d}$	熱傳送係數 U-值
$P = \frac{1}{2}\rho A v^3$	風力渦輪機的最大功率

醫學物理學

$\theta \approx \frac{1.22\lambda}{d}$	瑞利判據 (解像能力)
焦強 $= \frac{1}{f}$	透鏡的焦強
$L = 10\log\frac{I}{I_0}$	強度級 (dB)
$Z = \rho c$	聲阻抗
$\alpha = \frac{I_r}{I_0} = \frac{(Z_2 - Z_1)^2}{(Z_2 + Z_1)^2}$	反射聲強係數
$I = I_0 e^{-\mu x}$	經過介質傳送的強度

A1.	$E = mc\,\Delta T$	加熱和冷卻時的能量轉移	D1.	$F = \frac{Q_1 Q_2}{4\pi\varepsilon_0 r^2}$	庫倫定律
A2.	$E = l\,\Delta m$	物態變化時的能量轉移	D2.	$E = \frac{Q}{4\pi\varepsilon_0 r^2}$	點電荷的電場強度
A3.	$pV = nRT$	理想氣體物態方程	D3.	$E = \frac{V}{d}$	平行板間的電場 (數值)
A4.	$pV = \frac{1}{3}Nm\overline{c^2}$	分子運動論方程	D4.	$R = \frac{\rho l}{A}$	電阻和電阻率
A5.	$E_K = \frac{3RT}{2N_A}$	氣體分子動能	D5.	$R = R_1 + R_2$	串聯電阻器
			D6.	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$	並聯電阻器
B1.	$F = m\frac{\Delta v}{\Delta t} = \frac{\Delta p}{\Delta t}$	力	D7.	$P = IV = I^2 R$	電路中的功率
B2.	力矩 $= F \times d$	力矩	D8.	$F = BQv\sin\theta$	磁場對運動電荷的作用力
B3.	$E_P = mgh$	重力勢能	D9.	$F = BIl\sin\theta$	磁場對載流導體的作用力
B4.	$E_K = \frac{1}{2}mv^2$	動能	D10.	$B = \frac{\mu_0 I}{2\pi r}$	長直導線所產生的磁場
B5.	$P = Fv$	機械功率	D11.	$B = \frac{\mu_0 NI}{l}$	螺線管中的磁場
B6.	$a = \frac{v^2}{r} = \omega^2 r$	向心加速度	D12.	$\varepsilon = N\frac{\Delta\Phi}{\Delta t}$	感生電動勢
B7.	$F = \frac{Gm_1 m_2}{r^2}$	牛頓萬有引力定律	D13.	$\frac{V_s}{V_p} \approx \frac{N_s}{N_p}$	變壓器副電壓和原電壓之比

C1.	$\Delta y = \frac{\lambda D}{a}$	雙縫干涉實驗中條紋的間距	E1.	$N = N_0 e^{-\lambda t}$	放射衰變定律
C2.	$d\sin\theta = n\lambda$	衍射光柵方程	E2.	$t_{\frac{1}{2}} = \frac{\ln 2}{k}$	半衰期和衰變常數
C3.	$\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$	單塊透鏡方程	E3.	$A = kN$	放射強度和未衰變的原子核數目
			E4.	$\Delta E = \Delta mc^2$	質能關係式

請勿在此頁書寫。

寫於此頁的答案，將不予評閱。

2021-DSE
物理
卷一 乙部

B

香港考試及評核局
2021年香港中學文憑考試

物理 試卷一
乙部：試題答題簿 B

本試卷必須用中文作答

乙部考生須知

(一) 宣布開考後，考生須首先在第 1 頁之適當位置填寫考生編號；並在第1、3、5、7 及9頁之適當位置貼上電腦條碼。

(二) 參閱甲部試卷封面的考生須知。

(三) **全部試題均須作答**。

(四) 答案須寫在本試題答題簿中預留的空位內。不可在各頁邊界以外位置書寫。寫於邊界以外的答案，將不予評閱。

(五) 如有需要，可要求派發方格紙及補充答題紙。每一紙張均須填寫考生編號、填畫試題編號方格，貼上電腦條碼，並用繩縛於**簿內**。

(六) 試場主任宣布停筆後，考生不會獲得額外時間貼上電腦條碼及填畫試題編號方格。

請在此貼上電腦條碼

考生編號										

題號	分數
1	8
2	9
3	11
4	8
5	9
6	14
7	10
8	10
9	5

A150C01B

乙部：全部試題均須作答。標有 * 的分題涉及延展部分的知識。把答案寫在預留的空位內。

1. 於標準大氣壓強下，以一個 150 W 浸沒式電熱器使一大燒杯的水保持沸騰。經過 5 分鐘後有 16 g 的水沸騰掉。散失至周圍環境的熱可忽略不計。

(a) 求水的汽化比潛熱 l。 (2 分)

一學生將一細小金屬球放進沸騰的水中。數分鐘後，該球被迅速移送至盛有 100 g 溫度為 20 °C 的水的發泡膠杯內。輕輕攪勻杯中的水，其所達最高溫度為 22 °C。
已知：水的比熱容 = 4200 J kg^{-1} °C^{-1}

(b) 估算金屬球的熱容量 C。 (2 分)

(c) 事實上，該球會帶着一些沸水至這杯水。根據這事實，解釋 C 的真值是高於還是低於在 (b) 所計算出的值。 (2 分)

寫於邊界以外的答案，將不予評閱。

寫於邊界以外的答案，將不予評閱。

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(d) 為減低因發泡膠杯而引致的誤差，另一學生建議用一形狀和大小相若的銅杯重複測量。解釋這建議是否有理。 (2 分)

寫於邊界以外的答案，將不予評閱。

寫於邊界以外的答案，將不予評閱。

續 後 頁

2. 一潛水員在海面輕敲一金屬氣樽使發出聲響。該聲響豎直行進至 30 m 下的海床並回聲至海面需時 0.04 s。

(a) 估算聲音在海水中的速率。 (2 分)

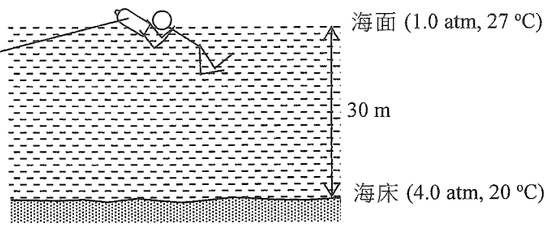

圖 2.1

金屬氣樽初始時在海面，其體積為 0.012 m^3，氣樽載有壓強為 18.5 atm 的壓縮氣體。海面的壓強為 1.0 atm 而溫度為 27 °C。潛水員隨後把氣樽帶往海床，海床的壓強為 4.0 atm 而溫度為 20 °C。假設金屬氣樽的體積保持不變。已知：大氣壓強 1.0 atm = 1.01×10^5 Pa

*(b)(i) 證明在海床時氣樽內的壓強變為 18.1 atm。 (1 分)

(ii) 以分子運動論解釋氣樽內的壓強下降。 (2 分)

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*(c)潛水員之後於海床以該樽壓縮氣體把一些相同的氣球充氣，每個充氣至體積 0.015 m^3。假設氣球緩慢充氣使氣體溫度保持不變，而氣球最終的壓強跟海床的相等。

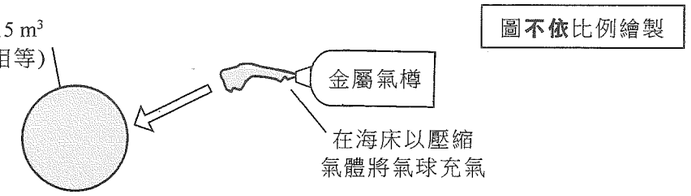


圖 2.2

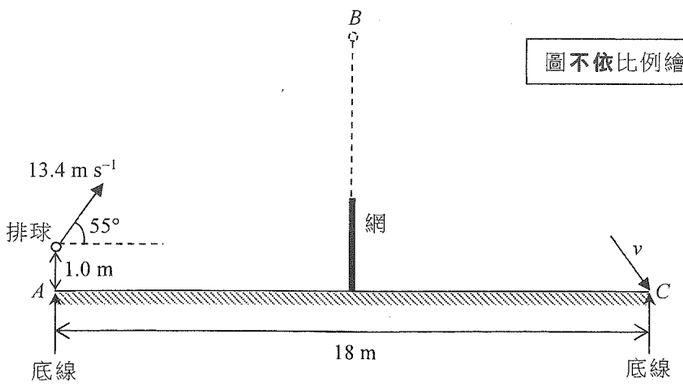
(i) 證明將一個氣球充氣後，氣樽內氣體的壓強下降了 5.0 atm。 (2 分)

(ii) 據此求潛水員總共可將多少個氣球完全充氣。 (2 分)

續 後 頁

3. 一排球員於球場的底線對上 1.0 m 的高度從靜止把球發出，球的初速為 13.4 m s^{-1} 並跟水平成 55° 角。球在跟底線垂直的豎直平面上運動，最終到達對方底線的 C 點，如圖 3.1 所示。排球的大小和空氣阻力可忽略不計。(g = 9.81 m s^{-2})

圖 3.1



(a) (i) 排球的質量為 0.22 kg。求該排球員對球所作的功。 (2 分)

(ii) 推算球撞擊地面上 C 點的速率 v。 (2 分)

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(b) 球場的長度 AC 為 18 m，而網設於 A 和 C 的中間。球需時 t 才到達在網豎直上方的 B 點。

(i) 指出球於 B 點時正在上升、水平飛行還是正在下降。 (1 分)

(ii) 求 t。 (2 分)

(c) 另一球員提議，倘以相若的初速但跟水平的夾角較小發球(例如 13.2 m s^{-1} 成 35° 角)，排球可以較短時間到達 C 點。毋須作任何計算，解釋這提議是否有理。 (2 分)

(d) 比賽時，排球員經常要跳躍和着地。根據力學原理，解釋為什麼排球場地面採用木料而非混凝土可有助保護球員以免受傷。 (2 分)

4. 如圖 4.1 所示，一小車以一條不能伸長的輕繩連接質量為 20 g 的掛鈎。小車上負載着四個有槽砝碼，每個質量為 20 g。這實驗是探究系統(小車、有槽砝碼及掛鈎)所受淨力跟其加速度的關係，將光滑水平跑道上的小車釋放後測量其加速度 a。

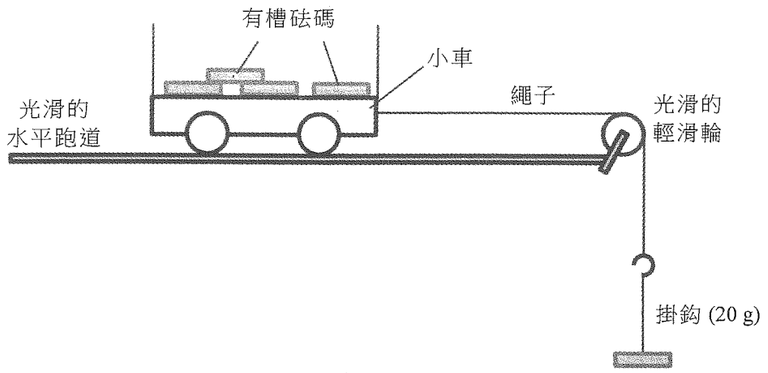


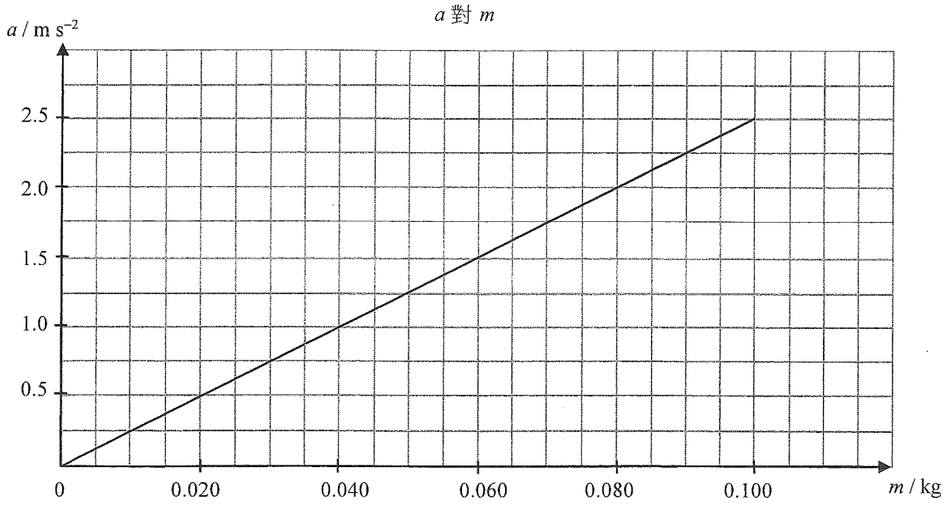
圖 4.1

將小車上的有槽砝碼逐一移至掛鈎，以增加懸吊着的質量 m 來重複實驗。

移至掛鈎的砝碼數量	0	1	2	3	4
懸吊着的質量 m / kg	0.020	0.040	0.060	0.080	0.100

以所得結果標繪 a 對 m 的線圖如下。空氣阻力和小車所受摩擦力皆略去不計。($g = 9.81\ m\ s^{-2}$)

a 對 m



寫於邊界以外的答案，將不予評閱。

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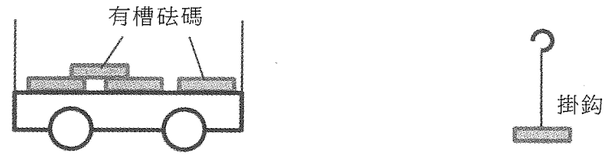
(a) (i) 當小車釋放後，在下面各圖中標示 (1) 負載着的小車沿水平方向所受的力，以及 (2) 掛鈎所受的力。 (2 分)



(ii) 當系統被釋放，繩子上的張力是等於、大於還是小於懸吊質量的重量？試解釋。 (2 分)

(iii) 藉着考慮整個系統的運動或以其他方法，寫出連繫 m、a 和小車質量 M 的方程。 (1 分)

(b) 計算線圖的斜率。據此利用 (a)(iii) 的結果求 M。 (3 分)

寫於邊界以外的答案，將不予評閱。

續 後 頁

5. 一火箭載着人造衛星從地球豎直發射。當火箭距地球表面某高度，它向着地球中心以某速率 v 每秒排出 2.60×10^3 kg 的氣體，因而產生 5.20×10^6 N 的平均推力。空氣阻力可忽略不計。

(a) (i) 假設火箭的速率可忽略不計，估算 v。 (2 分)

(ii) 在某一刻，火箭和人造衛星的總質量為 3.60×10^5 kg，而火箭所處位置的重力加速度為 8.56 m s^{-2}。估算火箭在這位置時的加速度 a。 (2 分)

(iii) 假設火箭的排氣率在數秒內維持不變，期間火箭的加速度會增加、減少還是保持不變？試解釋。 (2 分)

*(b) 該人造衛星被放進環繞地球而半徑為 r 的地球靜止軌道。對於在赤道上的某觀察者，該衛星看似一直靜止於上空。

(i) 指出該衛星的週期。 (1 分)

(ii) 證明 r 約為 42000 km。($g = 9.81$ m s^{-2}) (2 分)
已知：地球半徑 $= 6.37 \times 10^6$ m

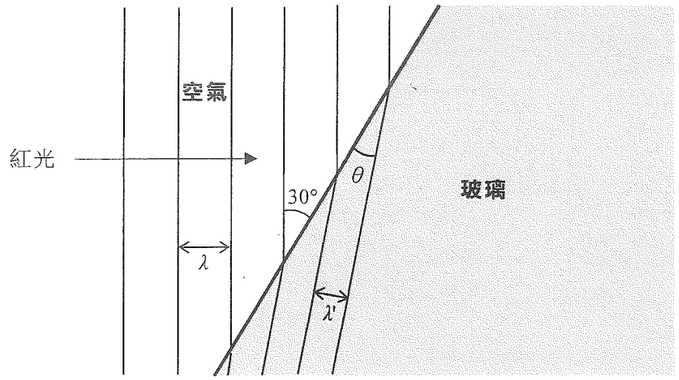
續 後 頁

請勿在此頁書寫。

寫於此頁的答案，將不予評閱。

6. (a) 如圖 6.1 所示，當波長 $\lambda = 675$ nm 的紅光以 30° 角從空氣入射玻璃會發生折射，以致其波長在玻璃中變為 $\lambda' = 450$ nm，折射角則為 θ。

圖 6.1



(i) 紅光在玻璃中的頻率是多少？ (2 分)

(ii) 求 θ。 (2 分)

(iii) 倘以藍光取代紅光，θ 會減小。試比較玻璃對紅光和藍光的折射率。 (1 分)

寫於邊界以外的答案，將不予評閱。

寫於邊界以外的答案，將不予評閱。

寫於邊界以外的答案，將不予評閱。

續 後 頁

6. (b) 圖 6.2 所示系統可將一透明的攝影幻燈片 O 投影到屏上。幻燈片與屏相距 1 m。以一束白光照亮幻燈片。調校透鏡 L 的位置，直至 O 在屏上形成清晰而線性放大至 9 倍的像。

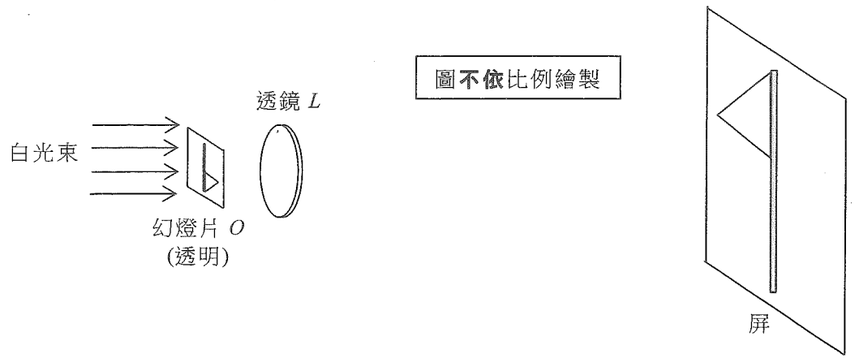
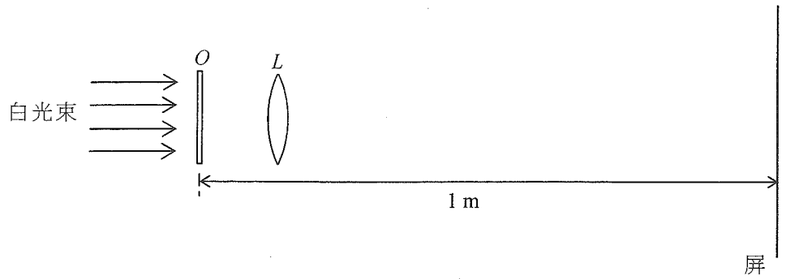


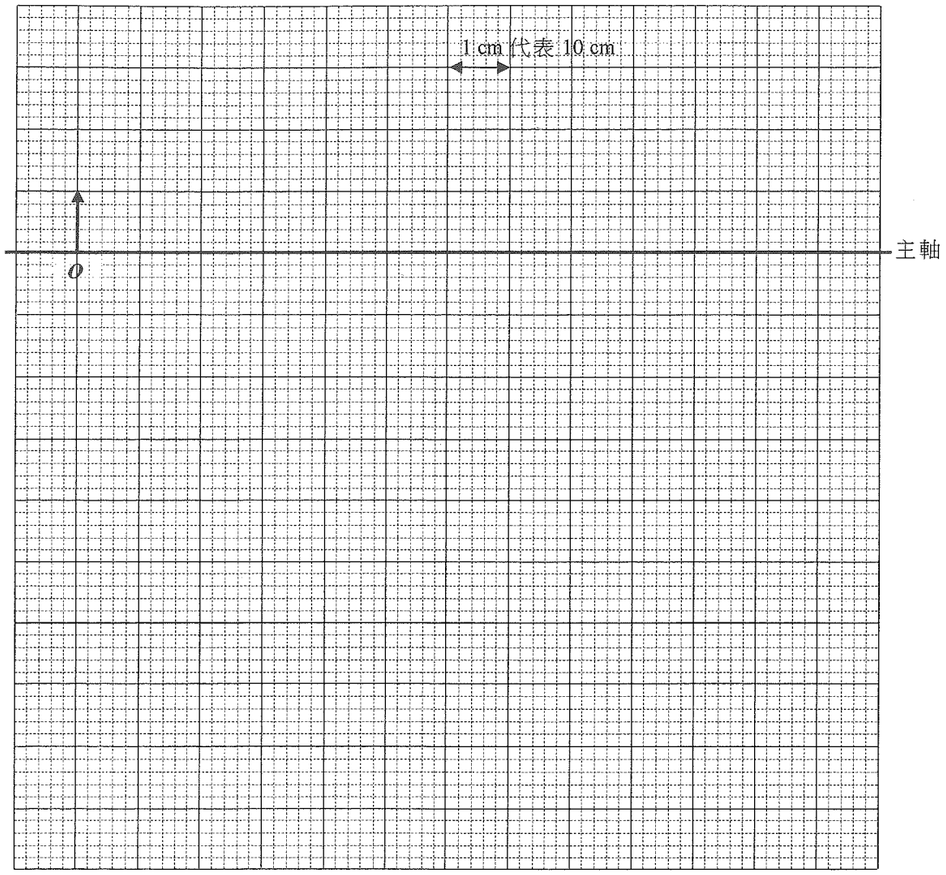
圖 6.2



(i) 指出該放大了的像的本質。 (1 分)

(ii) 求 O 與 L 的間距。 (1 分)

(iii) 繪畫一光線圖以顯示幻燈片 O 的像怎樣在屏上形成。在圖中標出透鏡 L 的焦點 F，並求 L 的焦距。(幻燈片 O 和透鏡的主軸已繪畫在圖中) (5 分)



L 的焦距 = _____

(iv) 當把一黑白的幻燈片投影到屏上，像的邊緣呈彩色。試簡單解釋。(提示：該透鏡是以玻璃製成的。) (2 分)

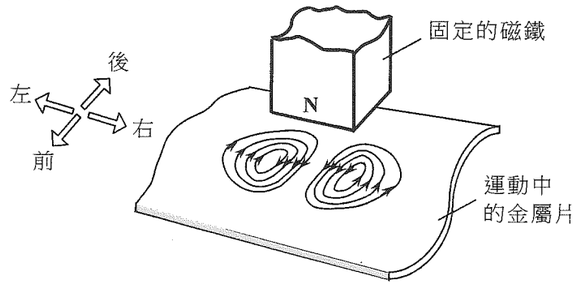
續 後 頁

7. 細閱以下有關「**渦電流**」的文章，並回答隨後的問題。

> 渦電流由變化的磁場所感生，並在導體中以閉環流動，猶如溪流中的旋渦，且跟磁場的方向垂直。它普遍應用於制動，稱為「渦流制動」。
>
> 渦電流的熱效應可用於感應生熱裝置，例如電磁爐。在導體中，渦電流遇到電阻便造成焦耳加熱。然而對某些應用而言，例如電動機和變壓器，所產生的熱會造成能量浪費，故此須盡量減少渦電流。
>
> 導體中的裂縫或縫隙可防止環流的流動，從而除去渦電流。故此渦電流可用於探測材料的缺陷。透過測量渦電流所產生的磁場，當磁場出現變化，則揭示材料有不規則的地方。

(a) (i) 在圖 7.1，一永久磁鐵被固定使其北極朝下。一運動中的金屬片(運動的方向沒有顯示)經過磁鐵，所感生的渦電流如圖所示。簡單解釋為何感生渦電流，並指出金屬片所作的運動是正在向前、向後、向左還是向右。 (2 分)

圖 7.1



(ii) 指出在金屬片減速至停下的過程中的各項能量變化。 (2 分)

(iii) 雖然渦流制動具非接觸的優點，但傳統的摩擦制動不能完全以渦流制動取代。為什麼？ (1 分)

(b) 一額定值為「220 V、2000 W」的電磁爐運作了 15 分鐘。如果 1 kW h 電能的收費是 $1.1，需付費多少？ (2 分)

(c) 指出一方法以減少在電動機和變壓器鐵心所產生的渦電流。 (1 分)

(d) 渦電流可用於探測材料的缺陷。當材料內有裂縫，由渦電流所產生的磁場會怎樣變化？試簡單解釋。 (2 分)

續 後 頁

8.

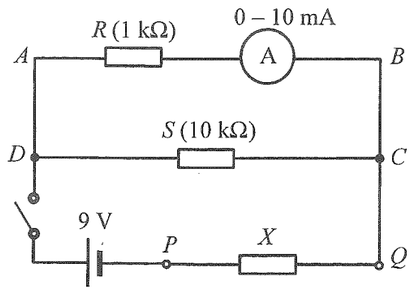


圖 8.1

圖 8.1 所示電路可測量跨接 P 和 Q 的電阻器 X 的電阻。電阻器 S 的電阻為 10 kΩ。9 V 電池以及安培計的內阻可略去不計。

(a) 當開關閉合，安培計的讀數為 8.5 mA。

(i) A 和 B 之間的電勢差是多少？ (2 分)

(ii) 求通過電阻器 S 的電流。 (2 分)

(iii) 在圖 8.1 標示接於 C 的三條支路上的電流方向。 (2 分)

(iv) 推斷電阻器 X 兩端的電勢差。據此求 X 的電阻值。 (3 分)

(b) 指出以電阻器 R 串聯連接安培計的目的。 (1 分)

寫於邊界以外的答案，將不予評閱。

寫於邊界以外的答案，將不予評閱。

9. 鉀-40 ($^{40}_{19}K$) 是鉀的一個天然放射性同位素。

(a) (i) 如果 $^{40}_{19}K$ 衰變成 $^{40}_{20}Ca$，$^{40}_{19}K$ 進行的是什麼衰變？ (1 分)

(ii) 由於香蕉含豐富的鉀，一學生認為進食了一些香蕉後，由 $^{40}_{19}K$ 發射出的輻射可於人體外探測得到。解釋這說法是否有理。 (1 分)

*(b) 每條香蕉一般含 0.45 g 鉀，當中以質量計 0.012% 為 $^{40}_{19}K$ 而其餘為 $^{39}_{19}K$。

已知：$^{40}_{19}K$ 的半衰期 $= 1.25 \times 10^9$ 年

1 年 $= 3.16 \times 10^7$ 秒

$^{40}_{19}K$ 的摩爾質量 $= 40.0$ g

(i) 估算一條香蕉所含 $^{40}_{19}K$ 的摩爾數。 (1 分)

(ii) 推算一條香蕉的放射強度，以 Bq 表達。 (2 分)

試卷完

本試卷所引資料的來源，將於香港考試及評核局稍後出版的《香港中學文憑考試試題專輯》內列明。

寫於邊界以外的答案，將不予評閱。

寫於邊界以外的答案，將不予評閱。

2021-DSE
物理
卷二

香 港 考 試 及 評 核 局
2 0 2 1 年 香 港 中 學 文 憑 考 試

物理　試卷二
試題答題簿

本試卷必須用中文作答
一小時完卷（上午十一時四十五分至下午十二時四十五分）

考生須知

(一) 宣布開考後，考生須首先在第 1 頁之適當位置填寫考生編號；並在第 1、3、5、7 及 9頁之適當位置貼上電腦條碼。

(二) 本試卷共有甲、乙、丙和丁**四部**。每部有八條多項選擇題和一條佔10分的結構式題目。考生須選答任何**兩部**中的**全部**試題。

(三) 結構式題目的答案須寫在所提供的**答題簿**中。多項選擇題應以HB鉛筆把與答案相應的圓圈塗滿。每題只可填畫**一個**答案，若填畫多個答案，則該題**不給分**。

(四) 如有需要，可要求派發方格紙及補充答題紙。每一紙張均須填寫考生編號、填畫試題編號方格，貼上電腦條碼，並用繩縛於**答題簿內**。

(五) 考試完畢，試題答題簿及答題簿須**分別**繳交。

(六) 本試卷的附圖**未必**依比例繪成。

(七) 試題答題簿最後兩頁附有本科常用的數據、公式和關係式以供參考。

(八) 試場主任宣布停筆後，考生不會獲得額外時間貼上電腦條碼及填畫試題編號方格。

請在此貼上電腦條碼

考生編號									

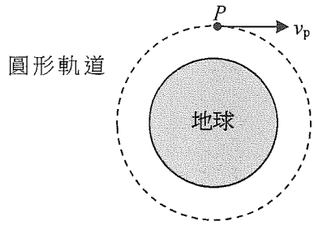
甲部：天文學和航天科學

Q.1：多項選擇題

1.1 參照下圖，在 P 給予一物體速率 v_P 而

$$v_1 < v_P < v_2$$

其中 v_1 為經過 P 的圓形軌道速率，而 v_2 為從 P 的逃逸速度。



下列哪項有關物體隨後運動的敘述**不正確**？

A. 它會沿一橢圓路徑飛行。
B. 它會以恆定速率沿其路徑飛行。
C. 它會在地球相反的一面某點離地球最遠。
D. 除 P 點外，它的飛行路徑不會與圓形軌道相交。

A ○ B ○ C ○ D ○

1.2 行星 X 和 Y 沿不同的圓形軌道繞一恆星運動。如果兩者週期之比 $\frac{X\text{的週期}}{Y\text{的週期}} = 8$，它們軌道半徑之比 $\frac{X\text{的半徑}}{Y\text{的半徑}}$ 是多少？

A. $\frac{1}{4}$
B. 4
C. $\frac{1}{16\sqrt{2}}$
D. $16\sqrt{2}$

A ○ B ○ C ○ D ○

1.3 下列哪項伽利略所作的觀察，跟宇宙的日心模型一致而與地心模型不一致？

(1) 火星的逆行運動
(2) 衛星環繞木星運動
(3) 金星相的改變

A. 只有 (1)
B. 只有 (2)
C. 只有 (1) 和 (2)
D. 只有 (2) 和 (3)

A ○ B ○ C ○ D ○

請在此貼上電腦條碼

1.4 下列哪項有關「視星等」和「絕對星等」的敘述**不正確**？

A. 一恆星的絕對星等可以大於其視星等。
B. 一恆星的絕對星等可以小於其視星等。
C. 如果一恆星的絕對星等跟另一恆星的視星等相同，每單位時間每單位面積從該兩恆星接收到的能量必定相等。
D. 如果一恆星的視星等跟另一恆星的視星等相同，每單位時間每單位面積從該兩恆星接收到的能量必定相等。

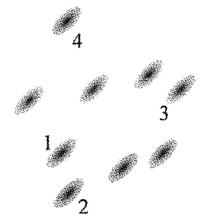
A ○ B ○ C ○ D ○

1.5 恆星 X 和 Y 的視亮度相同。恆星 X 的視差為恆星 Y 的兩倍。$\frac{\text{恆星 } X \text{ 的光度}}{\text{恆星 } Y \text{ 的光度}}$ 之比是多少？

A. $\frac{1}{4}$
B. $\frac{1}{2}$
C. 2
D. 4

A ○ B ○ C ○ D ○

1.6 下圖顯示一組星系的快照。



以下哪項敘述正確？

(1) 對於在星系 1 的觀察者，星系 4 的吸收譜線所顯示的紅移較星系 2 的大。
(2) 對於在星系 2 的觀察者，星系 4 比星系 1 以較高的速率遠離。
(3) 對於在星系 3 的觀察者，星系 1 和星系 4 以大約相同的速率遠離。

A. 只有 (1)
B. 只有 (1) 和 (2)
C. 只有 (2) 和 (3)
D. (1)、(2) 和 (3)

A ○ B ○ C ○ D ○

續 後 頁

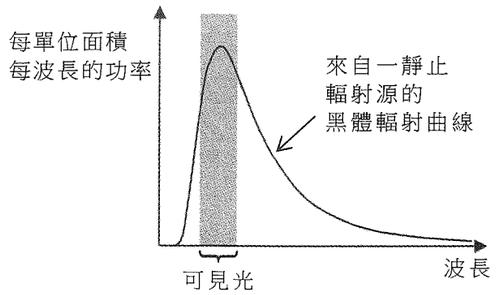
1.7 恆星的哪些資料可從其吸收光譜推斷得到？

(1) 它的光譜類型
(2) 它的徑向速度
(3) 它核心的化學成份

A. 只有 (1) 和 (2)
B. 只有 (1) 和 (3)
C. 只有 (2) 和 (3)
D. (1)、(2) 和 (3)

A B C D
○ ○ ○ ○

1.8



就正在遠離地球的輻射源，下列哪項有關其黑體輻射的多普勒頻移的敍述正確？

(1) 觀察所得黑體輻射曲線的峰向右移。
(2) 從觀察所推斷出該輻射源的溫度低於其實際值。
(3) 從觀察所得該輻射源的顏色跟靜止的輻射源的看起來會不同。

A. 只有 (1)
B. 只有 (1) 和 (2)
C. 只有 (1) 和 (3)
D. (1)、(2) 和 (3)

A B C D
○ ○ ○ ○

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Q.1：結構式題目

在我們的星系中，於距離地球 7940 pc 處有一強烈的無線電波發射源名為 Sgr A*。一恆星 X 繞着 Sgr A* 於一橢圓軌道運動，週期為 16.0 年。

(a) (i) 已知恆星 X 軌道的半長軸 a 的角大小為 0.125″。試求 a 的值，以 AU 為單位。 (1 分)

(ii) 據此應用開普勒第三定律於橢圓軌道 $T^2 = \frac{4\pi^2 a^3}{GM}$，證明 Sgr A* 的質量約為太陽質量的 3.82×10^6 倍。 (2 分)

(b) 如圖 1.1 所示，地球上一觀察者對準恆星 X 橢圓軌道 $ABCD$ 的半長軸。沿視線方向 X 的徑向速度 v_r 的變化如下面的線圖所示：當物體離開觀察者 v_r 取為正，物體趨近觀察者則 v_r 取為負。而 Sgr A* 可能處於位置 1 或 2。

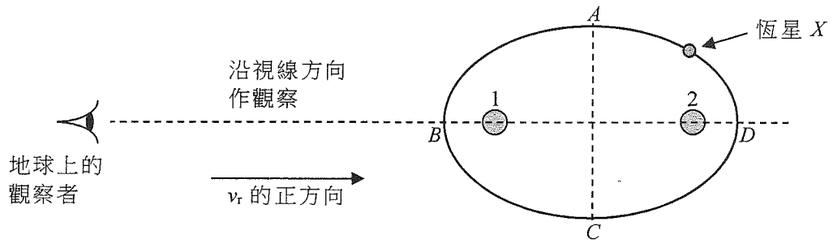
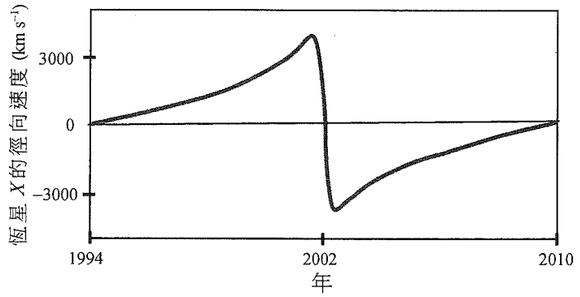


圖 1.1



(i) 提出確定 v_r 的一個方法。指出就 v_r 為正和負時，在該方法中觀察上的差異。 (2 分)

(ii) 指出大概在 2002 年時，恆星 X 是位於 A、B、C 還是 D。據此確定 Sgr A* 的位置 (位置 1 或位置 2)，並解釋你的選擇。 (2 分)

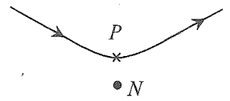
(c) 對於一質量為 M 和半徑為 R 的球形天體，從其表面的逃逸速度為 $v = \sqrt{\frac{2GM}{R}}$，其中 G 為萬有引力常數。科學家相信 Sgr A* 是一黑洞，並假設其表面有着極強的引力場，即使光亦未能逃逸。利用上述方程和 (a)(ii) 的結果，估算這黑洞 (假設質量為球形分布) 的半徑，以 AU 為單位。已知：$GM_S = 1.33 \times 10^{20}\ \text{N m}^2\ \text{kg}^{-1}$，其中 M_S 為太陽的質量。 (3 分)

續 後 頁

乙部：原子世界

Q.2：多項選擇題

2.1 一 α 粒子趨近一位於 N 的大質量原子核，其路徑如下圖所示。α 粒子在 P 點最為接近原子核。

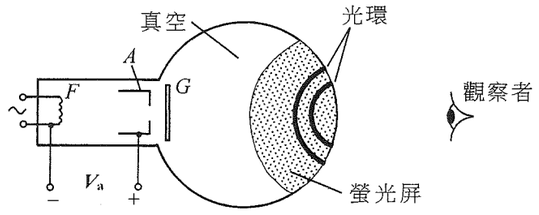


下列哪項敍述正確？

A. α 粒子的動能在 P 時為最大。
B. α 粒子的總能量在 P 時為最小。
C. 如果原子核的原子序數較大，P 和 N 之間的距離會大些。
D. 如果 α 粒子初始時有較大的動能，P 和 N 之間的距離會大些。

A ○ B ○ C ○ D ○

2.2 圖示的電子衍射管可揭示電子的本質。



被加熱的燈絲 F 釋出電子，並通過 F 和陽極 A 之間的高電壓 V_a 加速。電子穿過一塊薄石墨片 G，並在螢光屏上形成光和暗的同心環，如圖所示。下列哪些有關這實驗的描述正確？

(1) 實驗演示快速運動的電子具有波的本質。
(2) 電子被石墨片衍射。
(3) 如果 V_a 稍為增加，環的半徑會增加。

A. 只有 (1) 和 (2)
B. 只有 (1) 和 (3)
C. 只有 (2) 和 (3)
D. (1)、(2) 和 (3)

A ○ B ○ C ○ D ○

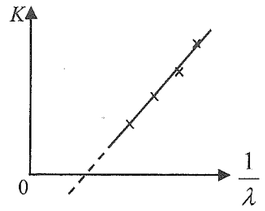
2.3 當波長為 λ 和 2λ 的單色光照射一金屬面，所發射光電子的最大動能之比為 3:1。求可觸發該金屬進行光電發射的單色光的最長波長。

A. $\frac{5\lambda}{2}$
B. 3λ
C. $\frac{7\lambda}{2}$
D. 4λ

A ○ B ○ C ○ D ○

請在此貼上電腦條碼

2.4 線圖顯示某金屬所發射出光電子的最大動能 K 跟入射光波長的倒數 $1/\lambda$ 的變化。

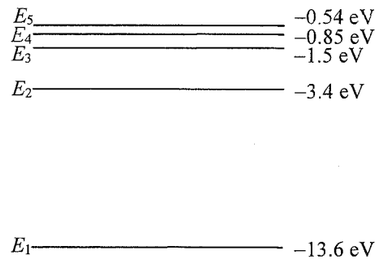


如以強度較低的入射光照射另一塊功函數較小的金屬，線圖會怎樣變化？

	線圖的斜率	水平軸的截距
A.	不變	較大
B.	不變	較小
C.	較小	較大
D.	較大	較小

A ○ B ○ C ○ D ○

2.5



圖示氫原子最低的五個能級。如果從 E_4 至 E_2 的電子躍遷會發射出藍光的光子，以下哪一電子躍遷會發射出紅光？已知：可見光譜約為 400 nm 至 750 nm

A. E_5 至 E_2
B. E_4 至 E_3
C. E_3 至 E_2
D. E_2 至 E_1

A ○ B ○ C ○ D ○

續 後 頁

2.6 當一質量為 m 而電荷為 e 的電子從靜止以電壓 V 加速，其德布羅意波長 λ 可表為 $\lambda=\frac{h}{\sqrt{2meV}}$，其中 h 為普朗克常數。如果 λ 以納米 (nm) 表達而 V 以千伏 (kV) 表達，則 λ 約為

A. $\frac{0.04}{\sqrt{V}}$。
B. $\frac{0.12}{\sqrt{V}}$。
C. $\frac{0.4}{\sqrt{V}}$。
D. $\frac{1.2}{\sqrt{V}}$。

A B C D
○ ○ ○ ○

2.7 下列哪些有關光學顯微鏡和透射電子顯微鏡 (TEM) 的敍述正確？

(1) TEM 可有較高解像能力，因為其電子束的波長遠較光學顯微鏡所用可見光的短。
(2) 在 TEM 中的載流線圈提供磁場使電子束會聚，這近似在光學顯微鏡中的透鏡把光會聚。
(3) 兩顯微鏡的角解像度皆受瑞利判據所限。

A. 只有 (1) 和 (2)
B. 只有 (1) 和 (3)
C. 只有 (2) 和 (3)
D. (1)、(2) 和 (3)

A B C D
○ ○ ○ ○

2.8 一種納米材料

(1) 的體積與表面面積之比高於同一材料於大塊形式時的值。
(2) 的尺寸至少有一邊小於 1 nm。
(3) 比同一材料於大塊形式時有較高的化學活躍度。

A. 只有 (1)
B. 只有 (3)
C. 只有 (1) 和 (2)
D. 只有 (2) 和 (3)

A B C D
○ ○ ○ ○

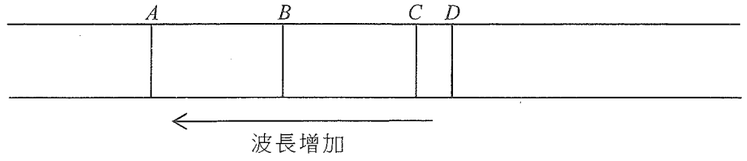
請在此貼上電腦條碼

Q.2：結構式題目

(a) 盧瑟福的行星原子模型未能解釋原子的穩定性。為什麼？ (1 分)

(b) 氫原子的發射光譜只有四條屬可見光範圍的譜線 (A 至 D)，如圖 2.1 所示。

圖 2.1



這些譜線屬於對應躍遷至第一受激態 ($n = 2$) 的光譜線系。這光譜線系中並無譜線在 A 之外。經驗得知以下公式代表該光譜線系全部譜線的波長 λ(單位 nm)。

$$\lambda = 364.6\left(\frac{n^2}{n^2-2^2}\right) \quad \text{其中 } n = 3, 4, 5, \cdots$$

(i) 哪一譜線 (A、B、C 還是 D) 源自能級 $n = 5$ 和 $n = 2$ 之間的電子躍遷？ (1 分)

(ii) 求 (b)(i) 的譜線的波長，並指出該條譜線的顏色。 (2 分)

(iii) 該光譜線系中其餘眾多看不見的譜線位於譜線 D 之外，並越來越互相靠近直至最終會聚於極限 364.6 nm。假設波長短於 364.6 nm 的一光子跟處於第一受激態 ($n = 2$) 的一氫原子碰撞，指出**該入射光子**、**氫原子**和**其軌道上的電子**會有什麼發生。 (3 分)

(iv) 初始時一群氫原子處於第三受激態 ($n = 4$)。附以能級圖展示**所有**可產生**發射譜線**的電子躍遷，並以字母「V」標註會產生可見光範圍譜線的躍遷。 (3 分)

續 後 頁

丙部：能量及能源的使用

Q.3：多項選擇題

3.1 一綠光源放出 1 W 光功率對應 683 lm 的光通量。考慮人眼的靈敏度，一發射白光的燈絲燈放出 1 W 光功率只產生約一半這光通量。如果燈絲燈的最終能源效益約為 3%，估算其發光效率。

A. 40 lm W^{-1}
B. 20 lm W^{-1}
C. 10 lm W^{-1}
D. 5 lm W^{-1}

A ○ B ○ C ○ D ○

3.2 風力渦輪發電機可提取流動空氣的能量。然而風的動能不能全部轉換成電能，因為

(1) 風速於風通過渦輪機後不能是零。
(2) 發電機轉換能量時有損失。
(3) 風並非總是正面吹着渦輪機。

A. 只有 (1) 和 (2)
B. 只有 (1) 和 (3)
C. 只有 (2) 和 (3)
D. (1)、(2) 和 (3)

A ○ B ○ C ○ D ○

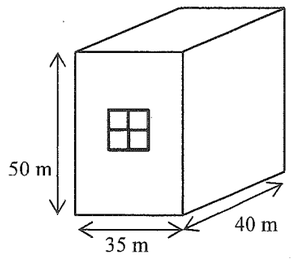
3.3 縱使天朗氣清，太陽功率至少有 26.8% 會被大氣吸收。面積為 5 m^2 的太陽能板其效率為 15%，求太陽能板的最大輸出功率。已知：太陽常數 = 1366 W m^{-2}

A. 275 W
B. 750 W
C. 1560 W
D. 4250 W

A ○ B ○ C ○ D ○

3.4 圖示一尺寸為 35 m × 40 m × 50 m 的混凝土建築物。已知建築物的總熱傳送值 (OTTV) 不應超過 24 W m^{-2}。如果該建築物內外之間的有效溫差為 10 °C，求建築物的牆上最多可安裝多少扇大小為 2 m × 3 m 的窗。

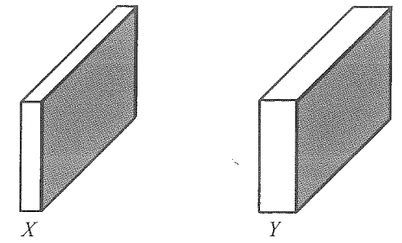
已知：建築物混凝土的 U-值 = 2.0 W m^{-2} K^{-1}
窗所用玻璃的 U-值 = 5.7 W m^{-2} K^{-1}



A. 960
B. 598
C. 160
D. 120

A ○ B ○ C ○ D ○

3.5



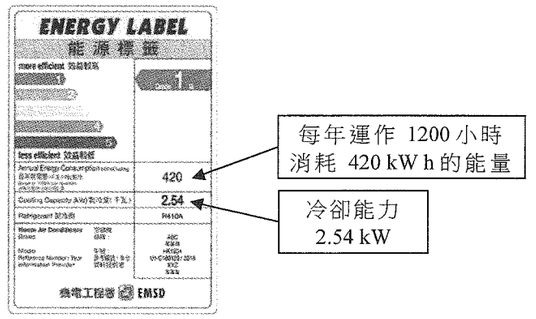
面積相同的牆 *X* 和 *Y* 以同一物料造成，而 *Y* 較 *X* 厚。如果每一牆兩面的溫差相同，*X* 和 *Y* 有着相同的

(1) 導熱率。
(2) 熱傳送係數 (U-值)。
(3) 每單位時間傳導的熱。

A. 只有 (1)
B. 只有 (3)
C. 只有 (1) 和 (2)
D. 只有 (2) 和 (3)

A ○ B ○ C ○ D ○

3.6 下面能源標籤顯示某空調機的資料。



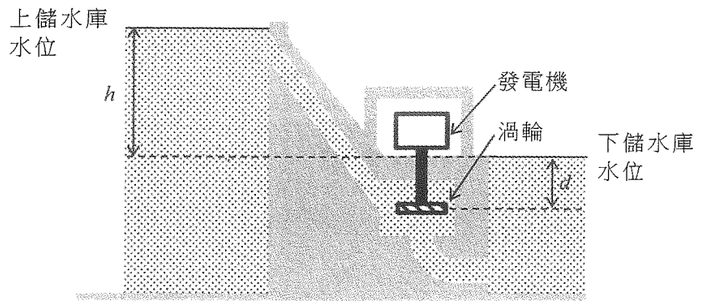
求該空調機的性能係數 (COP)。

A. 1.12
B. 1.38
C. 7.26
D. 8.89

A ○ B ○ C ○ D ○

續 後 頁

3.7 下圖顯示一水力發電廠。



以下哪些因素可影響發電廠的最大輸出功率？

(1) 上儲水庫和下儲水庫水位的高度差 h。
(2) 渦輪與下儲水庫水位的距離 d。
(3) 水通過渦輪的流率。

A. 只有 (1) 和 (2)
B. 只有 (1) 和 (3)
C. 只有 (2) 和 (3)
D. (1)、(2) 和 (3)

A ○ B ○ C ○ D ○

3.8 以下為一 U-235 原子核的裂變反應，當中的質量虧損為 0.1855u。

$$^{235}_{92}\mathrm{U} + {}^{1}_{0}\mathrm{n} \rightarrow {}^{94}_{40}\mathrm{Zr} + {}^{139}_{52}\mathrm{Te} + 3{}^{1}_{0}\mathrm{n}$$

當 1 kg 的 U-235 全部進行了該裂變，會釋出多少能量 (以 J 為單位)？
已知：U-235 的摩爾質量 = 235 g
1 u 的質量虧損會釋出 1.49×10^{-10} J 的能量

A. $\frac{1000}{235} \times 6.02 \times 10^{23} \times 0.1855 \times 1.49 \times 10^{-10}$
B. $\frac{1}{235} \times 6.02 \times 10^{23} \times 0.1855 \times 1.49 \times 10^{-10}$
C. $\frac{235}{1000} \times 6.02 \times 10^{23} \times 0.1855 \times 1.49 \times 10^{-10}$
D. $\frac{1000}{235} \times 6.02 \times 10^{23} \times 1.49 \times 10^{-10}$

A ○ B ○ C ○ D ○

Q.3：結構式題目

有關電動車 *A* 和 *B* 的一些資料表列如下：

電動車	電池組的容量 / kW h	最大行駛里程 / km	質量 / kg
A	95	326	2500
B	66	414	1620

(a) 雖然 *A* 的電池組容量較高，但它的最大行駛里程較 *B* 的短。指出一個可能的原因並解釋為什麼。 (1 分)

(b) (i) 如果所提供的充電電壓為 220 V，將已完全放電的 *A* 車電池組於 12 小時內完全充電，估算所需最小的充電電流。 (2 分)

(ii) 解釋為什麼實際需要的充電電流較 (b)(i) 所求得的大。 (1 分)

下表提供更多有關兩電動車的資料：

電動車	從 0 加速至 100 km h^{-1} 所需時間 / s	峰值功率 / kW
A	5.5	300
B	6.5	150

根據所提供的所有資料，估算

(c) (i) *A* 車的能源效益。你可假設車輛以峰值功率運作。 (2 分)

(ii) *B* 車電池組的平均輸出功率，若它在最大行駛里程測試中的平均速率為 70 km h^{-1}。 (2 分)

(d) 試討論再生制動系統於下列哪一種行駛模式能發揮最大效用： (2 分)

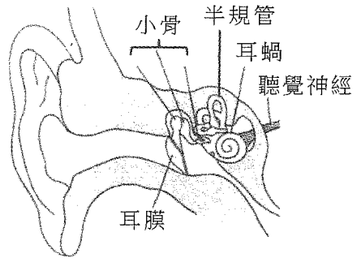
模式 1	在經常開車停車的交通情況中以每小時數公里行駛
模式 2	在以紅綠燈調節的城市交通中暢順行駛
模式 3	在高速公路行駛

續 後 頁

丁部：醫學物理學

Q.4：多項選擇題

4.1 耳朵的哪部分負責分辨頻率 ？



A. 耳膜
B. 半規管
C. 小骨
D. 耳蝸

A B C D
○ ○ ○ ○

4.2 一內窺鏡中的每條光導纖維由纖芯和將其覆蓋的包覆層組成，而纖芯和包覆層以不同的透明物料造成。下列哪些有關光導纖維的描述正確 ？

(1) 包覆層的折射率較纖芯的小。
(2) 纖芯-包覆層邊界所成的臨界角較纖芯-空氣邊界的小。
(3) 倘沒有包覆層，部分光線會在光導纖維相互的接觸點穿過。

A. 只有 (1) 和 (2)
B. 只有 (1) 和 (3)
C. 只有 (2) 和 (3)
D. (1)、(2) 和 (3)

A B C D
○ ○ ○ ○

4.3 下列有關超聲波成像 A-掃描和 B-掃描的描述，哪些正確 ？

(1) B-掃描於確定腫瘤位置較為有用。
(2) B-掃描可用以實時觀察器官的活動。
(3) B-掃描有較高解像度。

A. 只有 (1) 和 (2)
B. 只有 (1) 和 (3)
C. 只有 (2) 和 (3)
D. (1)、(2) 和 (3)

A B C D
○ ○ ○ ○

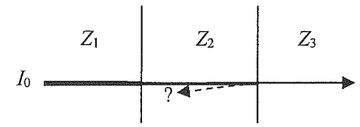
4.4 於診斷腦部創傷時，醫生以電腦斷層造影 (CT) 來確定內出血的位置。就這情況而言，以下造影方法**未被**採用的原因，哪些是正確的 ？

(1) X 射線放射攝影：因其解像度不足。
(2) 超聲波掃描：因超聲波不能穿過頭骨。
(3) 內窺鏡：因腦內沒有空腔給內窺鏡插入。

A. 只有 (1) 和 (2)
B. 只有 (1) 和 (3)
C. 只有 (2) 和 (3)
D. (1)、(2) 和 (3)

A B C D
○ ○ ○ ○

4.5 一束強度為 I_0 的狹窄超聲波穿過三個有不同聲阻抗 Z_1、Z_2 和 Z_3 的介質，如圖所示。



假設超聲波的衰減和吸收可忽略。於聲阻抗為 Z_2 和 Z_3 的介質間的分界面，所反射超聲波的強度是多少 ？

A. $\left[1-\dfrac{(Z_2-Z_1)^2}{(Z_2+Z_1)^2}\right]\dfrac{(Z_3-Z_2)^2}{(Z_3+Z_2)^2}\,I_0$

B. $\dfrac{(Z_2-Z_1)^2}{(Z_2+Z_1)^2}\dfrac{(Z_3-Z_2)^2}{(Z_3+Z_2)^2}\,I_0$

C. $\dfrac{(Z_2-Z_1)^2}{(Z_2+Z_1)^2}\left[1-\dfrac{(Z_3-Z_2)^2}{(Z_3+Z_2)^2}\right]I_0$

D. $\left[1-\dfrac{(Z_2-Z_1)^2}{(Z_2+Z_1)^2}\right]\left[1-\dfrac{(Z_3-Z_2)^2}{(Z_3+Z_2)^2}\right]I_0$

A B C D
○ ○ ○ ○

4.6 一 X 射線束穿過一厚度為 0.01 m 的金屬板後，其強度減少了 25%。求該 X 射線束相應的半值厚度。

A. 0.005 m
B. 0.020 m
C. 0.024 m
D. 0.042 m

A B C D
○ ○ ○ ○

續 後 頁

4.7 放射性核素成像只使用 γ 輻射的原因是

(1) γ 可被磁場偏折，使其以任何角度入射病者。
(2) γ 的致電離能力較低，對細胞的損害較小。
(3) γ 的貫穿能力較高，在身體外可檢測得到。

A. 只有 (1)
B. 只有 (3)
C. 只有 (1) 和 (2)
D. 只有 (2) 和 (3)

A	B	C	D
○	○	○	○

4.8 下列為計算有效劑量時不同輻射的輻射比重因子：

α 輻射	20
β 輻射	1
γ 輻射	1
X 射線	1

α 的輻射比重因子較大是因為

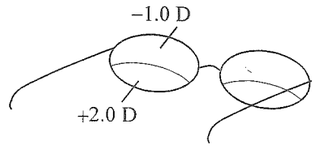
A. 它的貫穿能力較低。
B. 它的致電離能力較強。
C. 它是氦原子核所以質量相對大些。
D. 它的本質是粒子。

A	B	C	D
○	○	○	○

Q.4：結構式題目

(a) 保羅有視覺缺陷，他需要配戴圖 4.1 所示的矯視眼鏡。每一鏡片上半和下半的焦強分別為 −1.0 D 和 +2.0 D。

圖 4.1

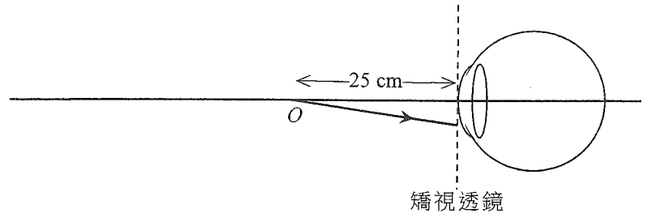


配戴眼鏡後，保羅的近點矯正至距離眼睛 25 cm，而遠點則矯正至無限遠。假設鏡片非常貼近他的眼睛。

(i) 指出鏡片哪一半使保羅能看清遙遠的物體。求他沒有配戴眼鏡時的遠點距離。 (2 分)

(ii) 圖 4.2 顯示一個點物體 O 放於矯視透鏡前 25 cm，矯視透鏡以虛線代表。

圖 4.2

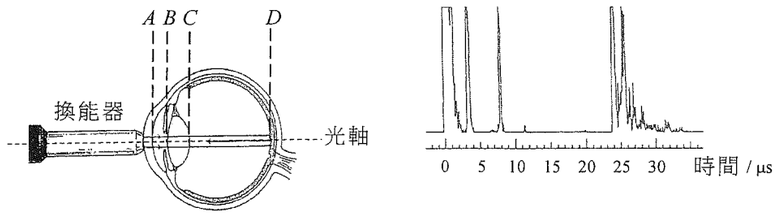


(1) **抄繪圖 4.2 到你的答題簿**，完成自 O 發出的光線如何到達視網膜的路徑。並於你的圖中標示保羅沒有配戴眼鏡時的近點 N。假設眼睛內的折射只在晶體進行。 (2 分)

(2) 計算 N 跟他眼睛的距離。 (2 分)

(b) 以超聲波換能器如圖 4.3 所示掃描眼睛。從分界面 A、B、C 和 D 反射的脈衝以 A-掃描記錄顯示如下。

圖 4.3



(i) 估算沿光軸的晶體厚度。已知：超聲波在晶體內的速度 = 1520 m s^{-1}。 (2 分)

(ii) 解釋以頻率 3 MHz 還是 15 MHz 的超聲波掃描眼睛較適合。 (1 分)

(iii) 除了在診斷中作掃描成像之外，寫出超聲波在醫學上的**一項**應用。 (1 分)

試卷完

本試卷所引資料的來源，將於香港考試及評核局稍後出版的《香港中學文憑考試試題專輯》內列明。

數據、公式和關係式

數據

摩爾氣體常數	$R = 8.31\ \text{J mol}^{-1}\ \text{K}^{-1}$
阿佛加德羅常數	$N_A = 6.02 \times 10^{23}\ \text{mol}^{-1}$
重力加速度	$g = 9.81\ \text{m s}^{-2}$ (接近地球)
萬有引力常數	$G = 6.67 \times 10^{-11}\ \text{N m}^2\ \text{kg}^{-2}$
在真空中光的速率	$c = 3.00 \times 10^8\ \text{m s}^{-1}$
電子電荷	$q_e = 1.60 \times 10^{-19}\ \text{C}$
電子靜止質量	$m_e = 9.11 \times 10^{-31}\ \text{kg}$
真空電容率	$\varepsilon_0 = 8.85 \times 10^{-12}\ \text{C}^2\ \text{N}^{-1}\ \text{m}^{-2}$
真空磁導率	$\mu_0 = 4\pi \times 10^{-7}\ \text{H m}^{-1}$
原子質量單位	$u = 1.661 \times 10^{-27}\ \text{kg}$ (1 u 相當於 931 MeV)
天文單位	$\text{AU} = 1.50 \times 10^{11}\ \text{m}$
光年	$\text{ly} = 9.46 \times 10^{15}\ \text{m}$
秒差距	$\text{pc} = 3.09 \times 10^{16}\ \text{m} = 3.26\ \text{ly} = 206265\ \text{AU}$
斯特藩常數	$\sigma = 5.67 \times 10^{-8}\ \text{W m}^{-2}\ \text{K}^{-4}$
普朗克常數	$h = 6.63 \times 10^{-34}\ \text{J s}$

直線運動

勻加速運動：

$$v = u + at$$
$$s = ut + \frac{1}{2}at^2$$
$$v^2 = u^2 + 2as$$

數學

直線方程	$y = mx + c$
弧長	$= r\theta$
柱體表面面積	$= 2\pi rh + 2\pi r^2$
柱體體積	$= \pi r^2 h$
球體表面面積	$= 4\pi r^2$
球體體積	$= \frac{4}{3}\pi r^3$
細小角度	$\sin\theta \approx \tan\theta \approx \theta$ (角度以 radians 表達)

天文學和航天科學

$U = -\frac{GMm}{r}$	引力勢能
$P = \sigma A T^4$	斯特藩定律
$\left\|\frac{\Delta f}{f_0}\right\| \approx \frac{v}{c} \approx \left\|\frac{\Delta\lambda}{\lambda_0}\right\|$	多普勒效應

能量和能源的使用

$E = \frac{\Phi}{A}$	照明度
$\frac{Q}{t} = \kappa\frac{A(T_H - T_C)}{d}$	傳導中能量的傳遞率
$U = \frac{\kappa}{d}$	熱傳送係數 U-值
$P = \frac{1}{2}\rho A v^3$	風力渦輪機的最大功率

原子世界

$\frac{1}{2}m_e v_{max}^2 = hf - \phi$	愛恩斯坦光電方程
$E_n = -\frac{1}{n^2}\left\{\frac{m_e q_e^4}{8h^2\varepsilon_0^2}\right\} = -\frac{13.6}{n^2}\text{ eV}$	氫原子能級方程
$\lambda = \frac{h}{p} = \frac{h}{mv}$	德布羅意公式
$\theta \approx \frac{1.22\lambda}{d}$	瑞利判據 (解像能力)

醫學物理學

$\theta \approx \frac{1.22\lambda}{d}$	瑞利判據 (解像能力)
焦強 $= \frac{1}{f}$	透鏡的焦強
$L = 10\log\frac{I}{I_0}$	強度級 (dB)
$Z = \rho c$	聲阻抗
$\alpha = \frac{I_r}{I_0} = \frac{(Z_2 - Z_1)^2}{(Z_2 + Z_1)^2}$	反射聲強係數
$I = I_0 e^{-\mu x}$	經過介質傳送的強度

A1.	$E = mc\,\Delta T$	加熱和冷卻時的能量轉移	D1.	$F = \frac{Q_1 Q_2}{4\pi\varepsilon_0 r^2}$	庫倫定律
A2.	$E = l\,\Delta m$	物態變化時的能量轉移	D2.	$E = \frac{Q}{4\pi\varepsilon_0 r^2}$	點電荷的電場強度
A3.	$pV = nRT$	理想氣體物態方程	D3.	$E = \frac{V}{d}$	平行板間的電場 (數值)
A4.	$pV = \frac{1}{3}Nm\overline{c^2}$	分子運動論方程	D4.	$R = \frac{\rho l}{A}$	電阻和電阻率
A5.	$E_K = \frac{3RT}{2N_A}$	氣體分子動能	D5.	$R = R_1 + R_2$	串聯電阻器
			D6.	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$	並聯電阻器
B1.	$F = m\frac{\Delta v}{\Delta t} = \frac{\Delta p}{\Delta t}$	力	D7.	$P = IV = I^2 R$	電路中的功率
B2.	力矩 $= F \times d$	力矩	D8.	$F = BQv\sin\theta$	磁場對運動電荷的作用力
B3.	$E_P = mgh$	重力勢能	D9.	$F = BIl\sin\theta$	磁場對載流導體的作用力
B4.	$E_K = \frac{1}{2}mv^2$	動能	D10.	$B = \frac{\mu_0 I}{2\pi r}$	長直導線所產生的磁場
B5.	$P = Fv$	機械功率	D11.	$B = \frac{\mu_0 NI}{l}$	螺線管中的磁場
B6.	$a = \frac{v^2}{r} = \omega^2 r$	向心加速度	D12.	$\varepsilon = N\frac{\Delta\Phi}{\Delta t}$	感生電動勢
B7.	$F = \frac{Gm_1 m_2}{r^2}$	牛頓萬有引力定律	D13.	$\frac{V_s}{V_p} \approx \frac{N_s}{N_p}$	變壓器副電壓和原電壓之比

C1.	$\Delta y = \frac{\lambda D}{a}$	雙縫干涉實驗中條紋的間距	E1.	$N = N_0 e^{-kt}$	放射衰變定律
C2.	$d\sin\theta = n\lambda$	衍射光柵方程	E2.	$t_{\frac{1}{2}} = \frac{\ln 2}{k}$	半衰期和衰變常數
C3.	$\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$	單塊透鏡方程	E3.	$A = kN$	放射強度和未衰變的原子核數目
			E4.	$\Delta E = \Delta m c^2$	質能關係式

2021-DSE
PHY

PAPER 1A

HONG KONG EXAMINATIONS AND ASSESSMENT AUTHORITY

HONG KONG DIPLOMA OF SECONDARY EDUCATION EXAMINATION 2021

PHYSICS PAPER 1

8:30 am – 11:00 am (2½ hours)

This paper must be answered in English

GENERAL INSTRUCTIONS

(1) There are **TWO** sections, A and B, in this Paper. You are advised to finish Section A in about 50 minutes.

(2) Section A consists of multiple-choice questions in this question paper, while Section B contains conventional questions printed separately in Question-Answer Book **B**.

(3) Answers to Section A should be marked on the Multiple-choice Answer Sheet while answers to Section B should be written in the spaces provided in the Question-Answer Book. **The Answer Sheet for Section A and the Question-Answer Book for Section B will be collected separately at the end of the examination.**

(4) The diagrams in this paper are **NOT** necessarily drawn to scale.

(5) The last two pages of this question paper contain a list of data, formulae and relationships which you may find useful.

INSTRUCTIONS FOR SECTION A (MULTIPLE-CHOICE QUESTIONS)

(1) Read carefully the instructions on the Answer Sheet. After the announcement of the start of the examination, you should first stick a barcode label and insert the information required in the spaces provided. No extra time will be given for sticking on the barcode label after the 'Time is up' announcement.

(2) When told to open this book, you should check that all the questions are there. Look for the words **'END OF SECTION A'** after the last question.

(3) All questions carry equal marks.

(4) **ANSWER ALL QUESTIONS.** You are advised to use an HB pencil to mark all the answers on the Answer Sheet, so that wrong marks can be completely erased with a rubber. You must mark the answers clearly; otherwise you will lose marks if the answers cannot be captured.

(5) You should mark only **ONE** answer for each question. If you mark more than one answer, you will receive **NO MARKS** for that question.

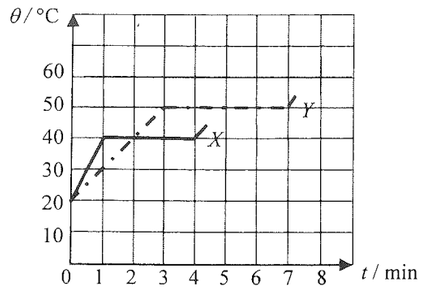
(6) No marks will be deducted for wrong answers.

Not to be taken away before the end of the examination session

Section A

There are 33 questions. Questions marked with * involve knowledge of the extension component.

1. Solid substances X and Y of equal mass are heated by heaters of power $2P$ and P respectively. The graph shows how the temperature θ of each substance varies with the heating time t.



What is the ratio of the specific latent heat of fusion of X to that of Y ?

A. 3 : 2
B. 3 : 4
C. 4 : 3
D. 2 : 3

2. Metal blocks X and Y are identical in size and shape. X is of a higher temperature than Y. Which of the following statements must be correct ?

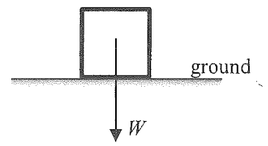
(1) Energy will flow from X to Y if they are in thermal contact.
(2) X is a better conductor of heat compared to Y.
(3) The total internal energy of X is higher than that of Y.

A. (1) only
B. (3) only
C. (1) and (2) only
D. (2) and (3) only

*3. For an ideal gas, kinetic theory deduces that $pV = \frac{1}{3} Nm\overline{c^2}$. Which physical quantity below can be represented by $\frac{3p}{\overline{c^2}}$?

A. the total mass of the gas
B. the volume of one mole of the gas
C. the density of the gas
D. the number of gas molecules per unit volume

4. A block of weight W is at rest on a horizontal ground as shown.



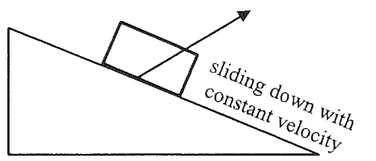
The force acting on the block by the ground is R. Which of the following statements is/are correct ?

(1) R and W are opposite in direction.
(2) R and W are equal in magnitude.
(3) R and W is an action-and-reaction pair.

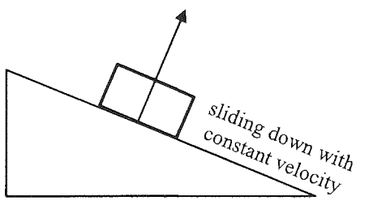
A. (1) only
B. (1) and (2) only
C. (2) and (3) only
D. (1), (2) and (3)

5. A block is sliding down a rough incline with constant velocity as shown. Which arrow indicates the direction of **the resultant force acting on the block by the incline** ? Neglect air resistance.

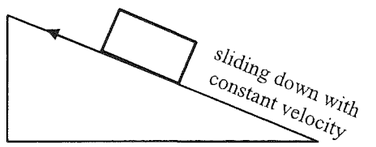
A.



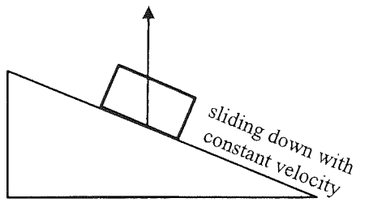
B.



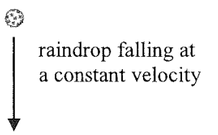
C.



D.



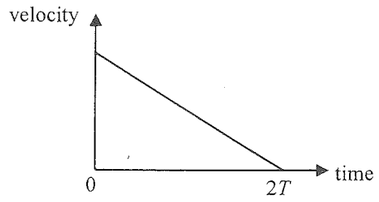
6. Which statement below about a raindrop falling at a constant terminal velocity is correct ?



A. No work is done on the raindrop by the gravitational force.
B. As the raindrop falls, all its gravitational potential energy loss is converted into kinetic energy gain.
C. The only force acting on the raindrop is its weight.
D. No net force is acting on the raindrop.

Go on to the next page

7. At time $t = 0$, a small sphere is projected up along a smooth incline with a certain initial velocity. It travels a distance L and becomes momentarily at rest after a time $2T$. The corresponding velocity-time graph is shown below.



What is the distance travelled by the sphere from $t = 0$ to $t = T$?

A. $\frac{1}{4}L$

B. $\frac{1}{2}L$

C. $\frac{3}{4}L$

D. $\frac{4}{5}L$

8. A stationary uranium nucleus $^{238}_{92}\text{U}$ decays to give a thorium nucleus $^{234}_{90}\text{Th}$ and an α particle $^{4}_{2}\text{He}$.

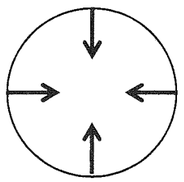
$$^{238}_{92}\text{U} \longrightarrow {}^{234}_{90}\text{Th} + {}^{4}_{2}\text{He}$$

Which of the following correctly describes the situation about the $^{234}_{90}\text{Th}$ nucleus and the α particle just after the decay ?

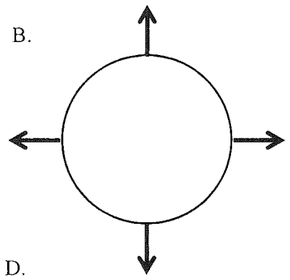
	magnitude of momentum p	kinetic energy KE
A.	$p(\text{Th}) = p(\alpha)$	$\text{KE(Th)} < \text{KE}(\alpha)$
B.	$p(\text{Th}) > p(\alpha)$	$\text{KE(Th)} > \text{KE}(\alpha)$
C.	$p(\text{Th}) = p(\alpha)$	$\text{KE(Th)} > \text{KE}(\alpha)$
D.	$p(\text{Th}) = p(\alpha)$	$\text{KE(Th)} = \text{KE}(\alpha)$

*9. A particle is moving clockwise (top view) in a horizontal circle with uniform speed. Which top view diagram below correctly shows the net force acting on the particle at various positions ?

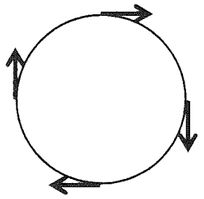
A.



B.



C.



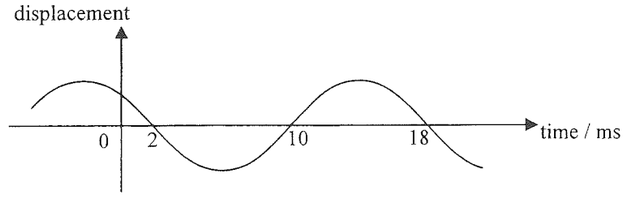
D.

10. Which of the following can be transferred by mechanical waves from one place to another along the direction of propagation ?

(1) mass
(2) momentum
(3) energy

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

11.



The displacement-time graph of a particle on a travelling wave is as shown. Find the frequency of the wave.

A. 55.6 Hz
B. 62.5 Hz
C. 111 Hz
D. 125 Hz

12. Earthquakes propagate in the form of waves. The quake centre produces both longitudinal waves (P-wave) and transverse waves (S-wave) which travel with speeds 9.6 km s^{-1} and 6.4 km s^{-1} respectively on the Earth's crust. In an earthquake, a monitoring station detects the arrival of the P-wave pulse at 7:02 a.m. while the S-wave pulse arrives 2 minutes later at 7:04 a.m. Estimate the time that this earthquake occurs.

A. 6:53 a.m.
B. 6:56 a.m.
C. 6:58 a.m.
D. 6:59 a.m.

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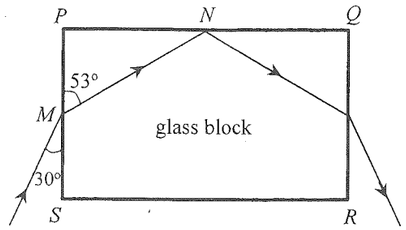
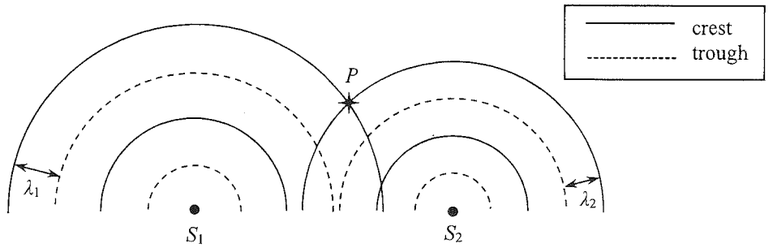
13.



The figure shows the cross-section of a rectangular glass block *PQRS*. A light ray is incident from air at *M* on face *PS* and the refracted ray strikes face *PQ* at *N*. Find the critical angle for the glass-air interface.

A. 37°
B. 44°
C. 53°
D. 60°

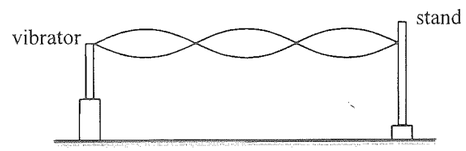
14. In a ripple tank, circular water waves of wavelengths λ_1 and λ_2 ($\lambda_1 > \lambda_2$) are produced by two vibrators S_1 and S_2 respectively. The figure represents the two circular waves propagating on the water surface at a certain moment.



Which of the following statements is correct ?

A. The particle at *P* is always at crest position.
B. At *P*, the two waves always reinforce to give a larger amplitude.
C. The principle of superposition cannot be applied at *P* as $\lambda_1 \neq \lambda_2$.
D. The principle of superposition can be applied at *P* but the two waves do not always reinforce at that location.

15. In the set-up below, different stationary wave patterns are formed on an elastic string by adjusting the frequency *f* of the vibrator.

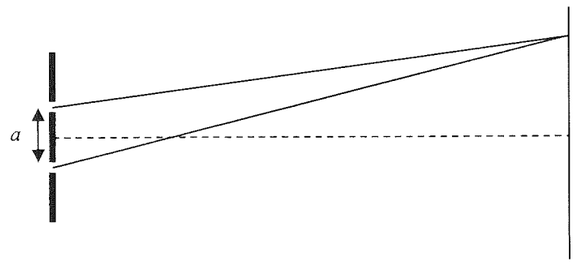


Which statements are correct when *f* increases ?

(1) The number of antinodes increases.
(2) The speed of the waves on the string increases.
(3) The frequency of the waves produced in air by the string increases.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

16. In Young's double slit experiment employing monochromatic light, how will the interference pattern change if the separation *a* of the double slit is reduced ?



(1) The pattern will become brighter.
(2) The number of fringes that can be observed will increase.
(3) The fringe separation of the pattern will become larger.

A. (1) only
B. (3) only
C. (1) and (2) only
D. (2) and (3) only

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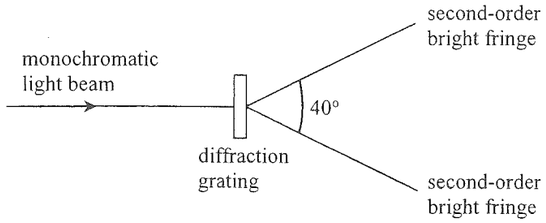
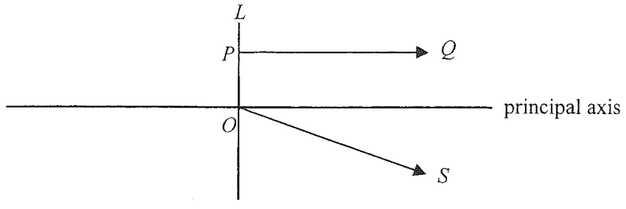
*17.



When a monochromatic light beam is incident normally on a diffraction grating with 300 lines per mm, a pattern of bright fringes is formed. The angle between the two second-order bright fringes is 40°. Find the frequency of the light.

A. 1.4×10^{14} Hz
B. 2.6×10^{14} Hz
C. 2.8×10^{14} Hz
D. 5.3×10^{14} Hz

18. In the figure below, PQ and OS are light rays refracted from a lens L. Both light rays come from a point object situated on the left of L.



Which of the following deductions is/are correct ?

(1) The image of the object must be virtual.
(2) The object must lie along the straight line containing OS.
(3) L must be a concave lens.

A. (1) only
B. (3) only
C. (1) and (2) only
D. (2) and (3) only

19. Typical wavelengths of X-rays and microwaves are in the ratio $10^n : 1$. The value of n could be

A. −10.
B. −4.
C. +4.
D. +10.

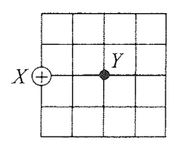
20. Submarines employ ultrasound instead of microwaves to detect obstacles in the sea. This is because

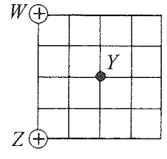
A. wavelengths of ultrasound are shorter than those of microwaves.
B. ultrasound travels faster than microwaves in the sea.
C. microwaves are easily absorbed by sea water.
D. microwaves diffract too much in the sea.

21. Three isolated identical metal spheres X, Y and Z carry charges $+2Q$, $-4Q$ and $+5Q$ respectively. Y is first moved to touch X and then Y is brought in contact with Z. When Y and Z are separated, find the charge on each sphere.

	X	Y	Z
A.	0	$+1.5Q$	$+1.5Q$
B.	$-Q$	$+0.5Q$	$+0.5Q$
C.	$+Q$	$+Q$	$+Q$
D.	$-Q$	$+2Q$	$+2Q$

*22. When a point charge $+Q$ is placed at X as shown, the strength of the electric field at Y is E_0.

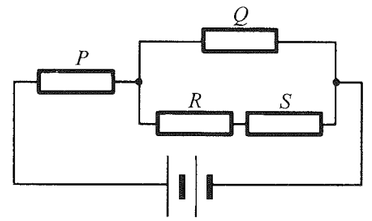




If W and Z are each placed with a point charge of $+Q$, what will be the electric field strength at Y ?
Note: $\sin 45° = \cos 45° = \frac{\sqrt{2}}{2}$

A. $\frac{\sqrt{2}}{2} E_0$
B. E_0
C. $\sqrt{2}\, E_0$
D. $2\, E_0$

23. Four identical resistors P, Q, R and S are connected to a battery of negligible internal resistance as shown.

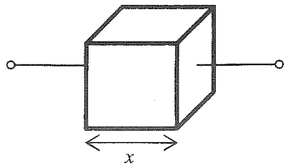


If the power dissipated by R is 1 W, find the total power output of the battery.

A. 11 W
B. 15 W
C. 19 W
D. 21 W

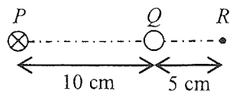
Go on to the next page

24. The figure shows a metallic cube of side length x. How is its resistance R between any two opposite faces related to x ?



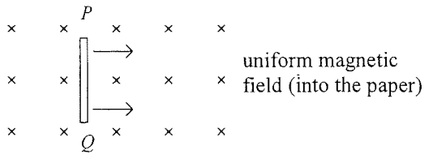
A. $R \propto \frac{1}{x}$
B. $R \propto x$
C. $R \propto x^2$
D. $R \propto \frac{1}{x^2}$

25. In the figure below, PQR is a straight line with $PQ = 10$ cm and $QR = 5$ cm. A long straight wire carrying a current of 0.3 A (directed into the paper) is placed at P. When another long straight wire carrying a current I is placed at Q, the resultant magnetic field at R becomes zero. Determine the direction and magnitude of I.



	direction of I	magnitude of I
A.	into the paper	0.1 A
B.	into the paper	0.9 A
C.	out of the paper	0.1 A
D.	out of the paper	0.9 A

26. When a copper rod PQ moves with a constant velocity across a uniform magnetic field as shown, an e.m.f. is induced across the rod.

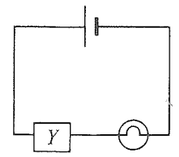


Which of the following statements is/are correct ?

(1) The magnitude of the induced e.m.f. depends on the length of the rod.
(2) Rod PQ acts like a cell providing an e.m.f. with P being its positive terminal.
(3) There is a force acting on the rod to oppose its motion.

A. (1) only
B. (3) only
C. (1) and (2) only
D. (2) and (3) only

27. A light bulb is connected in series with a device Y and a cell as shown. Assume that the internal resistance of the cell is negligible and its e.m.f. remains unchanged.

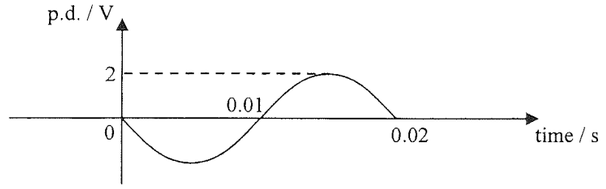


It is found that the brightness of the light bulb decreases with time. Which deductions must be correct ?

(1) The current in Y decreases with time.
(2) The voltage across Y decreases with time.
(3) The power supplied by the cell decreases with time.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

*28. The graph shows the waveform of a sinusoidal alternating p.d. applied across a 10 Ω resistor.

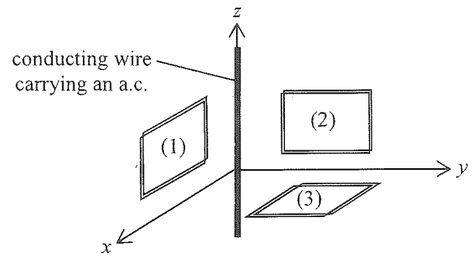


Find the root-mean-square current in this 10 Ω resistor and the average power dissipated by it.

	root-mean-square current / A	average power / W
A.	0.14	0.2
B.	0.14	0.4
C.	0.2	0.2
D.	0.2	0.4

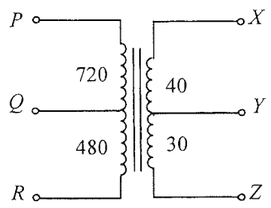
Go on to the next page

29. The figure shows three mutually perpendicular coils (1), (2) and (3) placed near a conducting wire carrying an a.c. along the z-axis direction. In which coil(s) would e.m.f. be induced ?



A. (1) only
B. (3) only
C. (1) and (2) only
D. (2) and (3) only

*30.



The above figure represents a multi-tapped transformer. The number of turns between the various 'tapping points' are indicated as shown. Which connections should be used for stepping down a voltage from 240 V to 6 V ?

	primary coil	**secondary coil**
A.	*PQ*	*XY*
B.	*PQ*	*YZ*
C.	*PR*	*XY*
D.	*PR*	*YZ*

31. A radioactive nuclide plutonium-239 ($^{239}_{94}Pu$) becomes a stable lead-207 isotope ($^{207}_{82}Pb$) after a series of α and β decays. Find the number of β decays in the process.

A. 3
B. 4
C. 5
D. 6

32. The activity of a radioactive sample is measured to be 18 MBq. What is its activity 3 half-lives before ?

A. 6 MBq
B. 54 MBq
C. 72 MBq
D. 144 MBq

33. Which of the following may contain sources of ionizing radiations ?

(1) sea water
(2) a rock sample
(3) human body

A. (1) only
B. (2) only
C. (2) and (3) only
D. (1), (2) and (3)

END OF SECTION A

List of data, formulae and relationships

Data

molar gas constant	$R = 8.31$ J mol^{-1} K^{-1}
Avogadro constant	$N_A = 6.02 \times 10^{23}$ mol^{-1}
acceleration due to gravity	$g = 9.81$ m s^{-2} (close to the Earth)
universal gravitational constant	$G = 6.67 \times 10^{-11}$ N m^2 kg^{-2}
speed of light in vacuum	$c = 3.00 \times 10^8$ m s^{-1}
charge of electron	$q_e = 1.60 \times 10^{-19}$ C
electron rest mass	$m_e = 9.11 \times 10^{-31}$ kg
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}$ C^2 N^{-1} m^{-2}
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}$ H m^{-1}
atomic mass unit	u $= 1.661 \times 10^{-27}$ kg (1 u is equivalent to 931 MeV)
astronomical unit	AU $= 1.50 \times 10^{11}$ m
light year	ly $= 9.46 \times 10^{15}$ m
parsec	pc $= 3.09 \times 10^{16}$ m $= 3.26$ ly $= 206265$ AU
Stefan constant	$\sigma = 5.67 \times 10^{-8}$ W m^{-2} K^{-4}
Planck constant	$h = 6.63 \times 10^{-34}$ J s

Rectilinear motion

For uniformly accelerated motion :

$$v = u + at$$
$$s = ut + \frac{1}{2}at^2$$
$$v^2 = u^2 + 2as$$

Mathematics

Equation of a straight line	$y = mx + c$
Arc length	$= r\theta$
Surface area of cylinder	$= 2\pi rh + 2\pi r^2$
Volume of cylinder	$= \pi r^2 h$
Surface area of sphere	$= 4\pi r^2$
Volume of sphere	$= \frac{4}{3}\pi r^3$

For small angles, $\sin\theta \approx \tan\theta \approx \theta$ (in radians)

Astronomy and Space Science

$U = -\frac{GMm}{r}$	gravitational potential energy
$P = \sigma AT^4$	Stefan's law
$\left\|\frac{\Delta f}{f_0}\right\| \approx \frac{v}{c} \approx \left\|\frac{\Delta\lambda}{\lambda_0}\right\|$	Doppler effect

Atomic World

$\frac{1}{2}m_e v_{max}^2 = hf - \phi$	Einstein's photoelectric equation
$E_n = -\frac{1}{n^2}\left\{\frac{m_e q_e^4}{8h^2\varepsilon_0^2}\right\} = -\frac{13.6}{n^2}$ eV	energy level equation for hydrogen atom
$\lambda = \frac{h}{p} = \frac{h}{mv}$	de Broglie formula
$\theta \approx \frac{1.22\lambda}{d}$	Rayleigh criterion (resolving power)

Energy and Use of Energy

$E = \frac{\Phi}{A}$	illuminance
$\frac{Q}{t} = \kappa\frac{A(T_H - T_C)}{d}$	rate of energy transfer by conduction
$U = \frac{\kappa}{d}$	thermal transmittance U-value
$P = \frac{1}{2}\rho Av^3$	maximum power by wind turbine

Medical Physics

$\theta \approx \frac{1.22\lambda}{d}$	Rayleigh criterion (resolving power)
power $= \frac{1}{f}$	power of a lens
$L = 10\log\frac{I}{I_0}$	intensity level (dB)
$Z = \rho c$	acoustic impedance
$\alpha = \frac{I_r}{I_0} = \frac{(Z_2 - Z_1)^2}{(Z_2 + Z_1)^2}$	intensity reflection coefficient
$I = I_0 e^{-\mu x}$	transmitted intensity through a medium

A1.	$E = mc\Delta T$	energy transfer during heating and cooling	D1.	$F = \frac{Q_1 Q_2}{4\pi\varepsilon_0 r^2}$	Coulomb's law
A2.	$E = l\Delta m$	energy transfer during change of state	D2.	$E = \frac{Q}{4\pi\varepsilon_0 r^2}$	electric field strength due to a point charge
A3.	$pV = nRT$	equation of state for an ideal gas	D3.	$E = \frac{V}{d}$	electric field between parallel plates (numerically)
A4.	$pV = \frac{1}{3}Nm\overline{c^2}$	kinetic theory equation	D4.	$R = \frac{\rho l}{A}$	resistance and resistivity
A5.	$E_K = \frac{3RT}{2N_A}$	molecular kinetic energy	D5.	$R = R_1 + R_2$	resistors in series
			D6.	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$	resistors in parallel
B1.	$F = m\frac{\Delta v}{\Delta t} = \frac{\Delta p}{\Delta t}$	force	D7.	$P = IV = I^2R$	power in a circuit
B2.	moment $= F \times d$	moment of a force	D8.	$F = BQv\sin\theta$	force on a moving charge in a magnetic field
B3.	$E_P = mgh$	gravitational potential energy	D9.	$F = BIl\sin\theta$	force on a current-carrying conductor in a magnetic field
B4.	$E_K = \frac{1}{2}mv^2$	kinetic energy	D10.	$B = \frac{\mu_0 I}{2\pi r}$	magnetic field due to a long straight wire
B5.	$P = Fv$	mechanical power	D11.	$B = \frac{\mu_0 NI}{l}$	magnetic field inside a long solenoid
B6.	$a = \frac{v^2}{r} = \omega^2 r$	centripetal acceleration	D12.	$\varepsilon = N\frac{\Delta\Phi}{\Delta t}$	induced e.m.f.
B7.	$F = \frac{Gm_1m_2}{r^2}$	Newton's law of gravitation	D13.	$\frac{V_s}{V_p} \approx \frac{N_s}{N_p}$	ratio of secondary voltage to primary voltage in a transformer

C1.	$\Delta y = \frac{\lambda D}{a}$	fringe separation in double-slit interference	E1.	$N = N_0 e^{-kt}$	law of radioactive decay
C2.	$d\sin\theta = n\lambda$	diffraction grating equation	E2.	$t_{\frac{1}{2}} = \frac{\ln 2}{k}$	half-life and decay constant
C3.	$\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$	equation for a single lens	E3.	$A = kN$	activity and the number of undecayed nuclei
			E4.	$\Delta E = \Delta mc^2$	mass-energy relationship

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Answers written on this page will not be marked.

2021-DSE
PHY
PAPER 1B

B

HONG KONG EXAMINATIONS AND ASSESSMENT AUTHORITY
HONG KONG DIPLOMA OF SECONDARY EDUCATION EXAMINATION 2021

PHYSICS PAPER 1

SECTION B : Question-Answer Book B

This paper must be answered in English

INSTRUCTIONS FOR SECTION B

(1) After the announcement of the start of the examination, you should first write your Candidate Number in the space provided on Page 1 and stick barcode labels in the spaces provided on Pages 1, 3, 5, 7 and 9.

(2) Refer to the general instructions on the cover of the Question Paper for Section A.

(3) Answer **ALL** questions.

(4) Write your answers in the spaces provided in this Question-Answer Book. Do not write in the margins. Answers written in the margins will not be marked.

(5) Graph paper and supplementary answer sheets will be provided on request. Write your Candidate Number, mark the question number box and stick a barcode label on each sheet, and fasten them with string **INSIDE** this Question-Answer Book.

(6) No extra time will be given to candidates for sticking on the barcode labels or filling in the question number boxes after the 'Time is up' announcement.

Please stick the barcode label here.

Candidate Number

Question No.	Marks
1	8
2	9
3	11
4	8
5	9
6	14
7	10
8	10
9	5

* A 1 5 0 E 0 1 B *

Section B: Answer **ALL** questions. Parts marked with * involve knowledge of the extension component. Write your answers in the spaces provided.

1. A 150 W immersion heater is used to keep the water in a large beaker boiling under standard atmospheric pressure. In 5 minutes, 16 g of water boils away. Neglect any heat loss to surroundings.

   (a) Find the specific latent heat of vaporization of water, l. (2 marks)

A student puts a small metal sphere in the boiling water. After a few minutes, the sphere is quickly transferred to a polystyrene cup containing 100 g of water at a temperature of 20 °C. The cup of water is stirred gently and its highest temperature attained is 22 °C.
Given: specific heat capacity of water = 4200 J kg^{-1} $°C^{-1}$

   (b) Estimate the heat capacity C of the metal sphere. (2 marks)

   (c) In fact the sphere has carried with it some boiling water to the cup of water. Referring to this fact, explain whether the true value of C is higher or lower than the value calculated in (b). (2 marks)

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   (d) In order to reduce the error contributed by the polystyrene cup, another student suggests repeating the measurements using a copper cup of similar shape and size. Explain whether the suggestion is justified. (2 marks)

Go on to the next page

2. A diver makes a sound by tapping a metal cylinder at sea level. Within a time of 0.04 s, the sound goes vertically to the seabed 30 m below and echoes back to the sea level.

(a) Estimate the speed of sound in sea water. (2 marks)

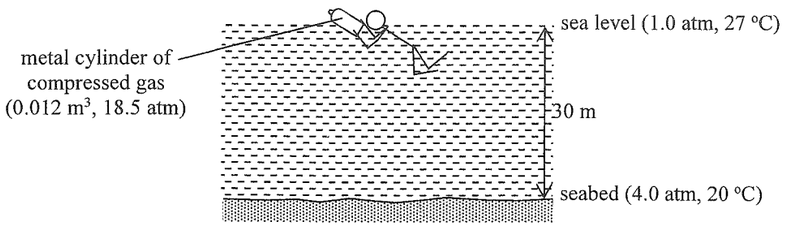

Figure 2.1

The metal cylinder of volume 0.012 m^3 contains compressed gas under a pressure of 18.5 atm is initially at sea level, where the pressure is 1.0 atm and the temperature is 27 °C. The diver then brings the cylinder to the seabed where the pressure is 4.0 atm and the temperature is 20 °C. Assume that the volume of the cylinder remains unchanged. Given: atmospheric pressure 1.0 atm = 1.01×10^5 Pa

*(b)(i) Show that at the seabed the pressure in the cylinder becomes 18.1 atm. (1 mark)

(ii) Explain the pressure drop in the cylinder using the kinetic theory. (2 marks)

Answers written in the margins will not be marked.

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*(c) The diver then inflates identical balloons each to a volume of 0.015 m^3 by using the cylinder of compressed gas at the seabed. Assume that the balloons are inflated slowly so that the temperature of the gas remains unchanged and the final pressure in the balloon equals that at the seabed.

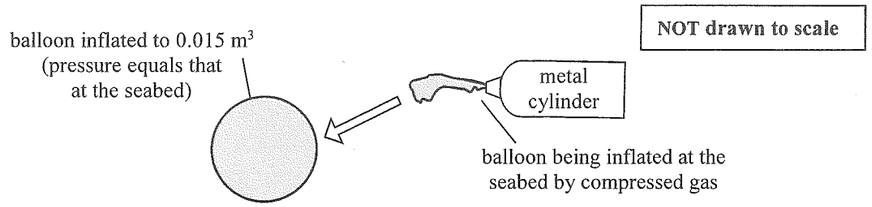

Figure 2.2

(i) Show that the gas pressure in the cylinder decreases by 5.0 atm after inflating one balloon. (2 marks)

(ii) Hence, find the total number of balloons that the diver can inflate completely. (2 marks)

Answers written in the margins will not be marked.

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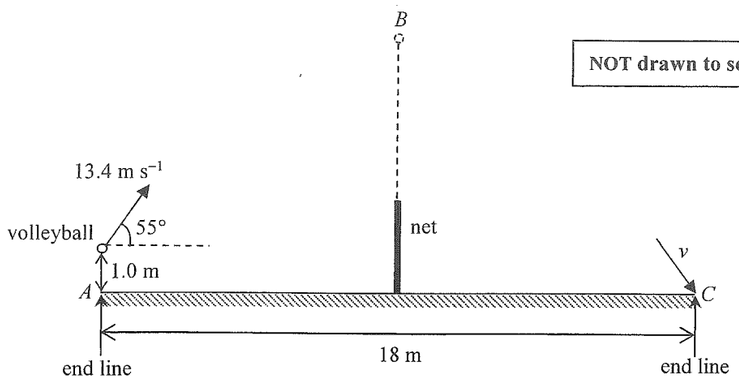
3. A volleyball player serves by hitting the ball from rest at a height of 1.0 m above the end line of the court. The initial speed of the ball is 13.4 m s^{-1} making an angle of 55° with the horizontal. It moves in a vertical plane perpendicular to the end line and finally reaches point C on the opposite end line as shown in Figure 3.1. Neglect the size of the ball and air resistance. ($g = 9.81$ m s^{-2})

Figure 3.1



(a) (i) The mass of the volleyball is 0.22 kg. Find the work done on the ball by the player. (2 marks)

(ii) Determine the speed v with which the ball hits point C on the ground. (2 marks)

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(b) The length of the court AC is 18 m and the net is positioned midway between A and C. It takes time t for the ball to reach point B which is vertically above the net.

(i) State whether the ball is ascending, flying horizontally or descending at B. (1 mark)

(ii) Find t. (2 marks)

(c) Another player suggests that the volleyball can reach point C in a shorter time if it is served with a similar initial speed but at a smaller angle with the horizontal (e.g. 13.2 m s^{-1} at an angle of 35°). Without doing any calculation, explain whether this suggestion is justified. (2 marks)

(d) Volleyball players have to jump and land frequently in a game. Referring to principles of mechanics, explain why volleyball courts with wood rather than concrete flooring may help to protect the players from injuries. (2 marks)

Go on to the next page

4. A trolley is connected to a hanger of mass 20 g by a light inextensible string as shown in Figure 4.1. Four slotted weights, each of mass 20 g, are loaded onto the trolley. The experiment is designed to investigate the relationship between the net force acting on the system (trolley and slotted weights with hanger) and its acceleration. The acceleration a is measured after the trolley is released on the smooth horizontal runway.

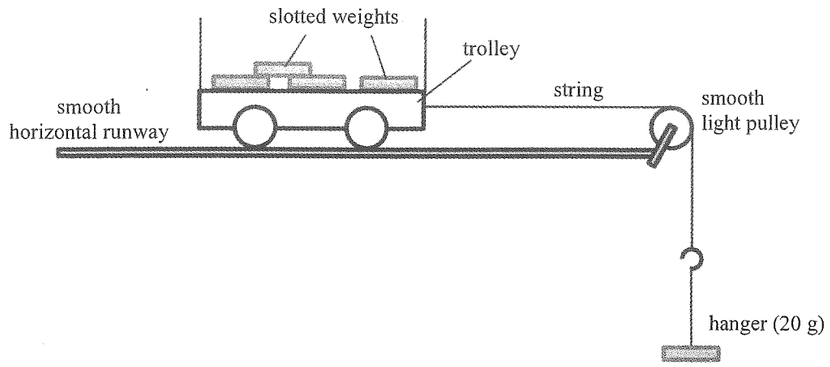
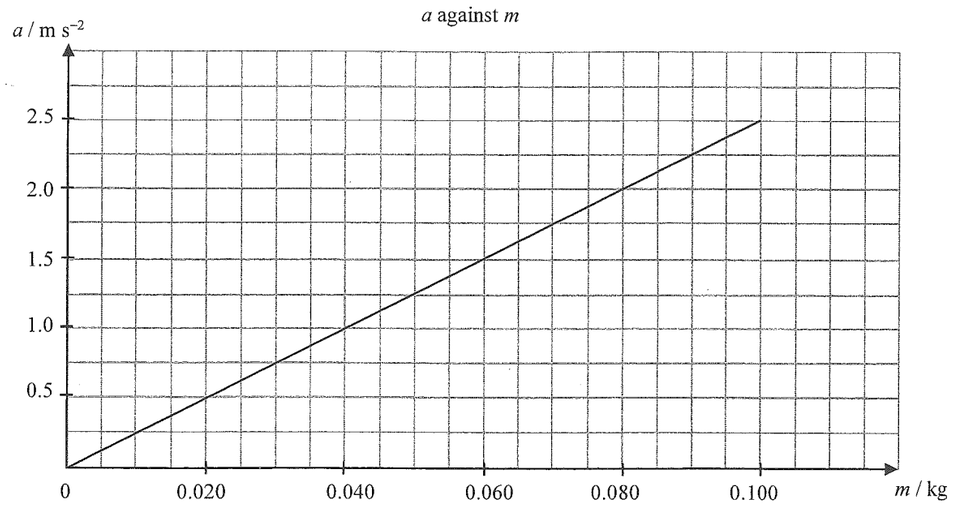


Figure 4.1

The experiment is repeated by transferring the slotted weights one by one from the trolley to the hanger so as to increase the mass hanging, m.

no. of weights transferred to the hanger	0	1	2	3	4
mass hanging m / kg	0.020	0.040	0.060	0.080	0.100

The results obtained are used for plotting a graph of a against m as shown below. Neglect both air resistance and the frictional forces acting on the trolley. ($g = 9.81$ m s^{-2})



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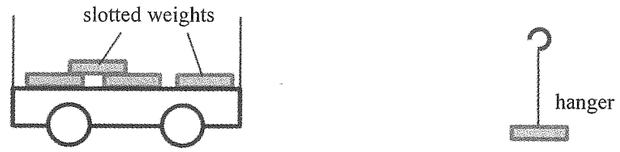
(a) (i) After the trolley is released, indicate in the figures below (1) the horizontal force(s) acting on the loaded trolley, and (2) the force(s) acting on the hanger. (2 marks)



(ii) Is the tension in the string equal to, greater than or smaller than the weight of the mass hanging when the system is released ? Explain. (2 marks)

(iii) By considering the motion of the whole system, or otherwise, write an equation relating m, a and mass M of the trolley. (1 mark)

(b) Calculate the slope of the graph. Hence find M using the result of (a)(iii). (3 marks)

Answers written in the margins will not be marked.

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5. A rocket carrying an artificial satellite is launched vertically from the Earth. When the rocket is at a certain height from the Earth's surface, it expels 2.60×10^3 kg of gas per second with a certain speed v towards the Earth's centre. As a result, an average thrust of 5.20×10^6 N is produced. Neglect air resistance.

(a) (i) Assuming that the speed of the rocket is negligible, estimate v. (2 marks)

(ii) At a certain instant, the total mass of the rocket and the artificial satellite is 3.60×10^5 kg while the acceleration due to gravity at the rocket's position is 8.56 m s^{-2}. Estimate the acceleration a of the rocket at this position. (2 marks)

(iii) Suppose the rocket keeps expelling gas at the same rate for a few seconds. Would the rocket's acceleration increase, decrease or remain unchanged in that duration ? Explain. (2 marks)

*(b) The artificial satellite is put in the geostationary orbit of radius r around the Earth. It appears to be always stationary above an observer at the equator.

(i) State the period of this satellite. (1 mark)

(ii) Show that r is approximately 42000 km. ($g = 9.81$ m s^{-2}) (2 marks)
Given: radius of the Earth = 6.37×10^6 m

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Do not write on this page.

Answers written on this page will not be marked.

6. (a) When red light of wavelength λ = 675 nm is incident at an angle of 30° from air to glass as shown in Figure 6.1, refraction occurs such that its wavelength in glass becomes λ' = 450 nm while the angle of refraction is θ.

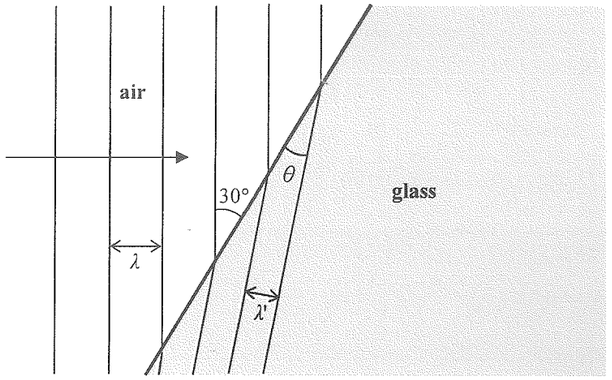

Figure 6.1

(i) What is the frequency of the red light in glass ? (2 marks)

(ii) Find θ. (2 marks)

(iii) If the red light is replaced by blue light, θ will decrease. Compare the refractive index of glass for the red light and blue light. (1 mark)

Answers written in the margins will not be marked.

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6. (b) Figure 6.2 shows a system for projecting a transparent photographic slide O onto a screen. The slide and the screen are 1 m apart. A beam of white light illuminates the slide. The position of lens L is adjusted until a sharp image of O magnified linearly to 9 times is formed on the screen.

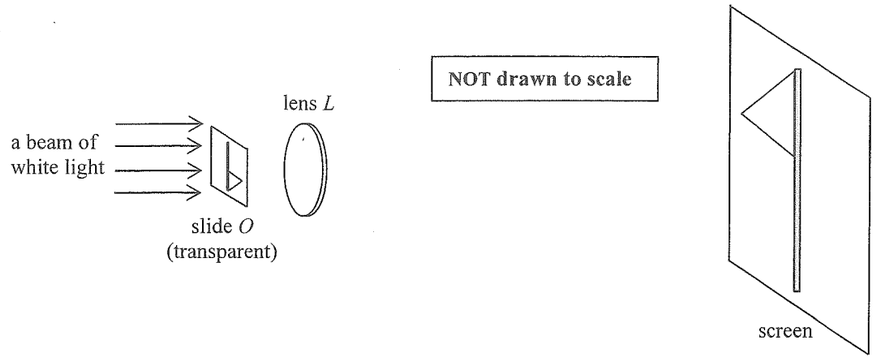
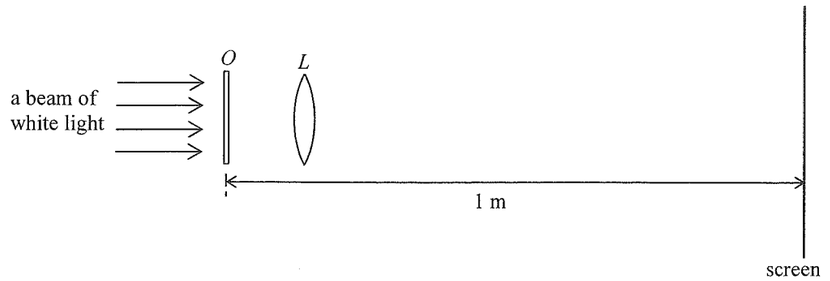


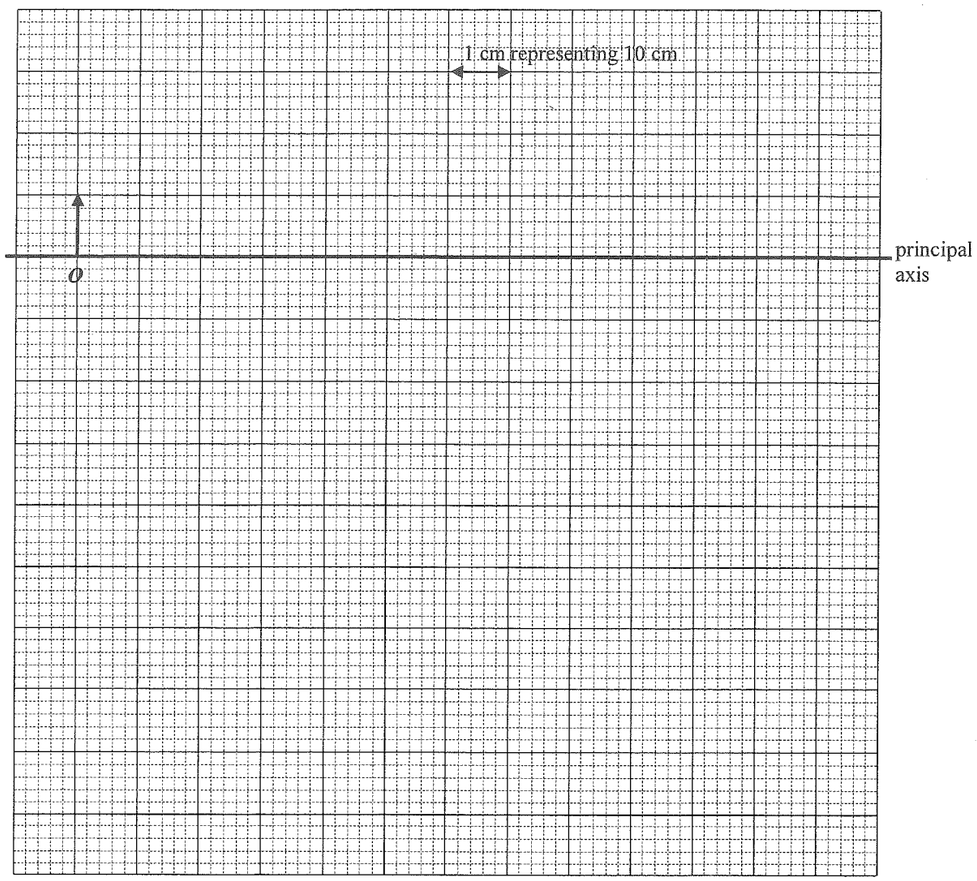
Figure 6.2



(i) State the nature of this magnified image. (1 mark)

(ii) Find the separation between O and L. (1 mark)

(iii) Draw a ray diagram to show how the image of slide O is formed on the screen. Locate the focus F of lens L on your diagram and find the focal length of L. (Slide O and the principal axis of the lens have been drawn for you.) (5 marks)



Focal length of L = ...

(iv) When a black-and-white slide is projected onto the screen, the image has colour edges. Explain briefly. (Hint: the lens is made of glass.) (2 marks)

Go on to the next page

7. Read the following passage about **eddy currents** and answer the questions that follow.

> Eddy currents are induced by changing magnetic fields. They flow in closed loops in conductors like swirling eddies in a stream, perpendicular to the direction of the magnetic field. They are commonly applied in braking known as 'eddy braking'.
>
> The heating effect of eddy currents is used in induction heating devices, such as induction cookers. The resistance felt by the eddy currents in a conductor causes Joule heating. However, for applications like motors and transformers, this heat is considered as a waste of energy and as such, eddy currents need to be minimized.
>
> Eddy currents can be removed by cracks or slits in the conductor, which prevent the current loops from circulating. This means that eddy currents can be used in detecting defects in materials. The magnetic field produced by the eddy currents is measured, where a change in the field reveals the presence of an irregularity in the material.

(a) (i) In Figure 7.1, a permanent magnet with north pole facing downwards is held stationary. A metal sheet moves past the magnet (the direction of movement is not shown) and eddy currents are induced as shown. Briefly explain why eddy currents are induced and state whether the metal sheet is moving forward, backward, towards the left or towards the right. (2 marks)

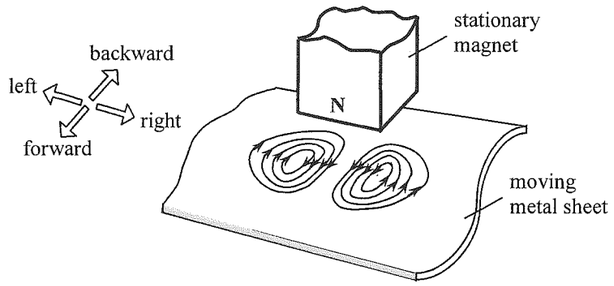


Figure 7.1

(ii) State the energy changes in the process in which the metal sheet is slowing down to stop. (2 marks)

(iii) Although eddy braking has the advantage of being contactless, traditional frictional braking cannot be totally replaced by eddy braking. Why ? (1 mark)

(b) An induction cooker of rating '220 V, 2000 W' operates for 15 minutes. How much should be paid if 1 kW h of electrical energy costs $1.1 ? (2 marks)

(c) State a method to minimize eddy currents produced in the iron cores of motors and transformers. (1 mark)

(d) Eddy currents can be used to detect defects in materials. When there is a crack in a material, how would the magnetic field due to eddy currents change ? Explain briefly. (2 marks)

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8.

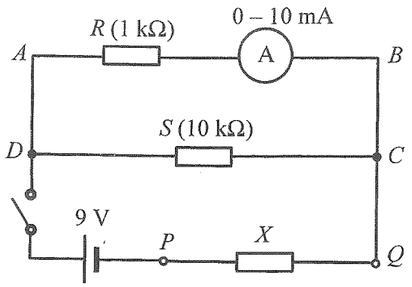


Figure 8.1

Figure 8.1 shows a circuit for measuring the resistance of resistor X connected across P and Q. The resistance of resistor S is 10 kΩ. The internal resistance of the 9 V cell and that of the ammeter are negligible.

(a) When the switch is closed, the ammeter reads 8.5 mA.

(i) What is the p.d. between A and B ? (2 marks)

(ii) Find the current passing through resistor S. (2 marks)

(iii) Indicate on Figure 8.1 the direction of current in each of the three branches via C. (2 marks)

(iv) Deduce the p.d. across resistor X. Hence, find the resistance of X. (3 marks)

(b) State the purpose of connecting resistor R in series with the ammeter. (1 mark)

9. Potassium-40 ($^{40}_{19}K$) is a natural radioisotope of potassium.

(a) (i) What kind of decay does $^{40}_{19}K$ undergo if it decays to $^{40}_{20}Ca$? (1 mark)

(ii) As banana is rich in potassium, a student claims that the radiation emitted by $^{40}_{19}K$ after eating a few bananas can be detected outside the human body. Explain whether this claim is justified. (1 mark)

*(b) A banana typically contains 0.45 g potassium in which 0.012% by mass is $^{40}_{19}K$ while the rest is $^{39}_{19}K$.

Given: half-life of $^{40}_{19}K = 1.25 \times 10^9$ years
1 year = 3.16×10^7 seconds
molar mass of $^{40}_{19}K = 40.0$ g

(i) Estimate the number of moles of $^{40}_{19}K$ in a banana. (1 mark)

(ii) Deduce the activity, in Bq, of a banana. (2 marks)

END OF PAPER

Sources of materials used in this paper will be acknowledged in the *HKDSE Question Papers* booklet published by the Hong Kong Examinations and Assessment Authority at a later stage.

2021-DSE
PHY

PAPER 2

HONG KONG EXAMINATIONS AND ASSESSMENT AUTHORITY

HONG KONG DIPLOMA OF SECONDARY EDUCATION EXAMINATION 2021

PHYSICS PAPER 2

Question-Answer Book

11:45 am – 12:45 pm (1 hour)
This paper must be answered in English

INSTRUCTIONS

(1) After the announcement of the start of the examination, you should first write your Candidate Number in the space provided on Page 1 and stick barcode labels in the spaces provided on Pages 1, 3, 5, 7 and 9.

(2) This paper consists of **FOUR** sections, Sections A, B, C and D. Each section contains eight multiple-choice questions and one structured question which carries 10 marks. Attempt **ALL** questions in any **TWO** sections.

(3) Write your answers to the structured questions in the **ANSWER BOOK** provided. For multiple-choice questions, blacken the appropriate circle with an HB pencil. You should mark only **ONE** answer for each question. If you mark more than one answer, you will receive **NO MARKS** for that question.

(4) Graph paper and supplementary answer sheets will be provided on request. Write your candidate number, mark the question number box and stick a barcode label on each sheet, and fasten them with string **INSIDE** the Answer Book.

(5) The Question-Answer Book and Answer Book will be collected **SEPARATELY** at the end of the examination.

(6) The diagrams in this paper are **NOT** necessarily drawn to scale.

(7) The last two pages of this Question-Answer Book contain a list of data, formulae and relationships which you may find useful.

(8) No extra time will be given to candidates for sticking on the barcode labels or filling in the question number boxes after the 'Time is up' announcement.

Please stick the barcode label here.

Candidate Number

A150E2MC

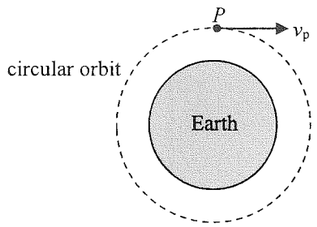
Section A : Astronomy and Space Science

Q.1: Multiple-choice questions

1.1 Referring to the figure below, an object at P is given a speed v_P such that

$$v_1 < v_P < v_2$$

where v_1 is the speed for the circular orbit passing through P and v_2 is the escape velocity from P.



Which statement about the subsequent motion of the object is **INCORRECT** ?

A. It will follow an elliptical flight path.
B. It will travel with constant speed along its flight path.
C. It will be farthest from the Earth at a point on the opposite side of the Earth.
D. Its flight path will not intersect the circular orbit except at point P.

A ○ B ○ C ○ D ○

1.2 Planets X and Y orbit a star in different circular orbits. What is the ratio of their orbital radii $\frac{\text{radius } X}{\text{radius } Y}$ if the ratio of their periods is $\frac{\text{period } X}{\text{period } Y} = 8$?

A. $\frac{1}{4}$
B. 4
C. $\frac{1}{16\sqrt{2}}$
D. $16\sqrt{2}$

A ○ B ○ C ○ D ○

1.3 Which of the following observations made by Galileo is/are consistent with the heliocentric model but not with the geocentric model of the universe ?

(1) retrograde motion of Mars
(2) moons revolving around Jupiter
(3) changing phases of Venus

A. (1) only
B. (2) only
C. (1) and (2) only
D. (2) and (3) only

A ○ B ○ C ○ D ○

Please stick the barcode label here.

1.4 Which statement about *apparent magnitude* and *absolute magnitude* is **INCORRECT** ?

A. The absolute magnitude of a star can be larger than its apparent magnitude.
B. The absolute magnitude of a star can be smaller than its apparent magnitude.
C. If the absolute magnitude of a star equals the apparent magnitude of another star, the energy received per unit time per unit area from these two stars must be equal.
D. If the apparent magnitude of a star equals the apparent magnitude of another star, the energy received per unit time per unit area from these two stars must be equal.

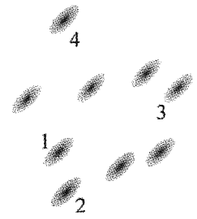
A ○ B ○ C ○ D ○

1.5 Stars X and Y are of equal apparent brightness. Parallax of star X is twice that of star Y. What is the ratio $\frac{\text{luminosity of star } X}{\text{luminosity of star } Y}$?

A. $\frac{1}{4}$
B. $\frac{1}{2}$
C. 2
D. 4

A ○ B ○ C ○ D ○

1.6 The figure shows a snapshot of a group of galaxies.



Which of the following statements is/are correct ?

(1) For observers in Galaxy 1, the absorption lines of Galaxy 4 shows a greater red shift than those of Galaxy 2.
(2) For observers in Galaxy 2, Galaxy 4 is moving away at a higher speed than Galaxy 1 is.
(3) For observers in Galaxy 3, Galaxy 1 and Galaxy 4 are moving away at roughly the same speed.

A. (1) only
B. (1) and (2) only
C. (2) and (3) only
D. (1), (2) and (3)

A ○ B ○ C ○ D ○

Go on to the next page

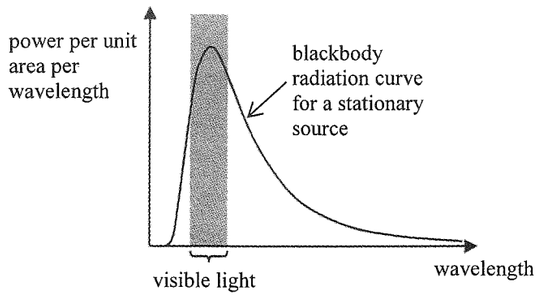
1.7 What information of a star can be deduced from its absorption spectrum ?

(1) its spectral class
(2) its radial velocity
(3) the chemical composition of its core

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

A	B	C	D
○	○	○	○

1.8



Which of the following statements about the Doppler shift of the blackbody radiation from a source moving away from the Earth is/are correct ?

(1) The peak of the blackbody radiation curve observed shifts to the right.
(2) The temperature of the source inferred from the observation is cooler than the actual value.
(3) The colour of the source observed looks different from that of a stationary source.

A. (1) only
B. (1) and (2) only
C. (1) and (3) only
D. (1), (2) and (3)

A	B	C	D
○	○	○	○

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Q.1: Structured question

In our galaxy, there is a strong radio wave emitting source known as Sgr A* which is located at a distance 7940 pc away from the Earth. A star X is found orbiting around Sgr A* in an elliptical orbit with a period of 16.0 years.

(a) (i) The semi-major axis of the orbit, a, of star X is known to have an angular size of 0.125″. Determine the value of a in units of AU. (1 mark)

(ii) Hence use Kepler's third law for elliptical orbits, $T^2 = \frac{4\pi^2 a^3}{GM}$, to show that the mass of Sgr A* is about 3.82×10^6 times the mass of the Sun. (2 marks)

(b) As shown in Figure 1.1, an observer on Earth is aligned with the semi-major axis of the elliptical orbit $ABCD$ of star X. The variation of the radial velocity v_r of X along the line of sight is shown in the graph below: v_r is taken to be positive for an object receding from the observer while a negative v_r implies an approaching object. The possible locations of Sgr A* are positions 1 or 2.

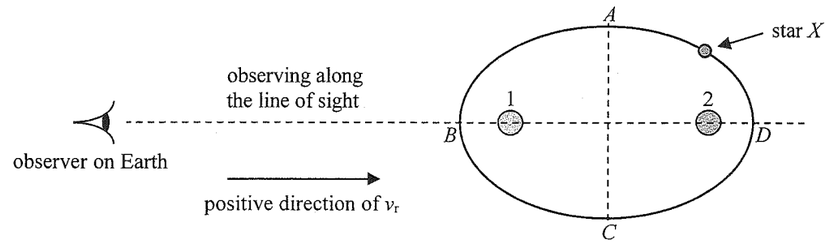
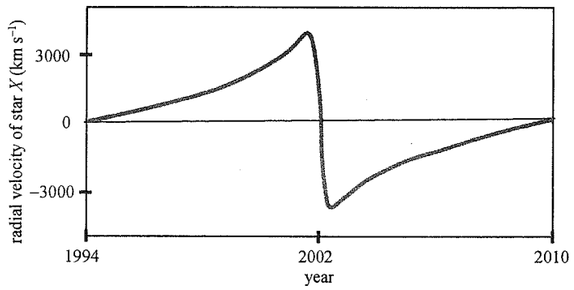


Figure 1.1



(i) Give one method to determine v_r. State the difference in observation for positive and negative values of v_r in your proposed method. (2 marks)

(ii) State where star X is located, A, B, C or D, around the year 2002. Hence determine the location of Sgr A* (position 1 or position 2). Explain your choice. (2 marks)

(c) For a spherical celestial body of mass M and radius R, the escape velocity from its surface is given by $v = \sqrt{\frac{2GM}{R}}$, where G is the universal gravitational constant. Scientists believe that Sgr A* is a black hole, which is supposed to have an extremely strong gravitational field on its surface that even light cannot escape. Using the above equation and the result of (a)(ii), estimate the radius of this black hole (assume spherical mass distribution) in units of AU. Given: $GM_S = 1.33 \times 10^{20}$ N m^2 kg^{-1}, where M_S is the mass of the Sun. (3 marks)

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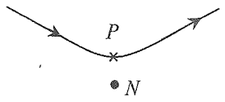
Section B : Atomic World

Q.2: Multiple-choice questions

2.1 The path of an α particle approaching a massive nucleus at N is shown below. At point P the α particle is closest to the nucleus.

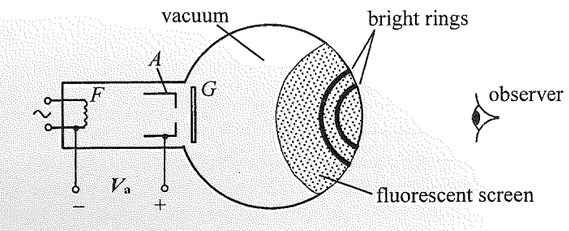


Which statement below is correct ?

A. At P the kinetic energy of the α particle is at a maximum.
B. At P the total energy of the α particle is at a minimum.
C. If the nucleus has a larger atomic number, the distance between P and N would be larger.
D. If the α particle has a larger initial kinetic energy, the distance between P and N would be larger.

A ○ B ○ C ○ D ○

2.2 The figure shows an electron diffraction tube that can reveal the nature of electrons.



Electrons liberated from a heated filament F are accelerated by a high voltage V_a between F and anode A. The electrons then pass through a thin graphite film G and form bright and dark concentric rings on a fluorescent screen as shown. Which descriptions about this experiment are correct ?

(1) It demonstrates the wave nature of fast-moving electrons.
(2) Electrons are diffracted by the graphite film.
(3) If V_a increases slightly, the radii of the rings would increase.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

A ○ B ○ C ○ D ○

2.3 When monochromatic lights of wavelengths λ and 2λ are incident on a metal surface, the maximum kinetic energies of the photoelectrons emitted are in the ratio of 3:1. Find the longest wavelength of monochromatic light that can trigger photoemission for such metal.

A. $\frac{5\lambda}{2}$
B. 3λ
C. $\frac{7\lambda}{2}$
D. 4λ

A ○ B ○ C ○ D ○

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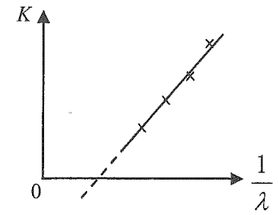
2.4 The graph shows the variation of the maximum kinetic energy K of the photoelectrons emitted from a certain metal with the reciprocal of the wavelength $1/\lambda$ of the incident light.

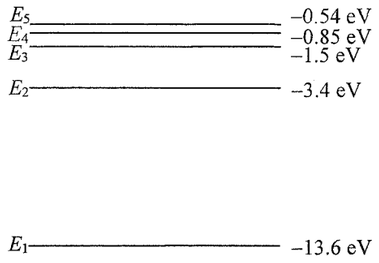


How would the graph change if incident light of lower intensity is shone on another metal having a smaller work function ?

	slope of the graph	**intercept on horizontal axis**
A.	unchanged	larger
B.	unchanged	smaller
C.	smaller	larger
D.	larger	smaller

A ○ B ○ C ○ D ○

2.5



The figure shows the five lowest energy levels of a hydrogen atom. If electron transition from E_4 to E_2 emits a photon of blue light, which electron transition below would emit red light ?
Given: the visible spectrum is about 400 nm to 750 nm

A. E_5 to E_2
B. E_4 to E_3
C. E_3 to E_2
D. E_2 to E_1

A ○ B ○ C ○ D ○

Go on to the next page

2.6 When an electron of mass m and charge e is accelerated from rest by a voltage V, its de Broglie wavelength λ is given by $\lambda = \frac{h}{\sqrt{2meV}}$, where h is the Planck constant. If λ is expressed in nanometre (nm) and V in kilovolt (kV), then λ is approximately equal to

A. $\frac{0.04}{\sqrt{V}}$.
B. $\frac{0.12}{\sqrt{V}}$.
C. $\frac{0.4}{\sqrt{V}}$.
D. $\frac{1.2}{\sqrt{V}}$.

A	B	C	D
○	○	○	○

2.7 Which statements about optical microscope and transmission electron microscope (TEM) are correct ?

(1) The higher resolving power of TEM is enabled by the much shorter wavelength of its electron beam than that of visible light employed in an optical microscope.
(2) The current-carrying coils in a TEM provide magnetic fields for converging the electron beam, which is similar to the lenses in an optical microscope for converging light.
(3) The angular resolution of both microscopes are limited by the Rayleigh's criterion.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

A	B	C	D
○	○	○	○

2.8 A nano material

(1) has a higher volume to surface area ratio than the same substance in bulk form.
(2) has at least one dimension less than 1 nm.
(3) is chemically more reactive than the same substance in bulk form.

A. (1) only
B. (3) only
C. (1) and (2) only
D. (2) and (3) only

A	B	C	D
○	○	○	○

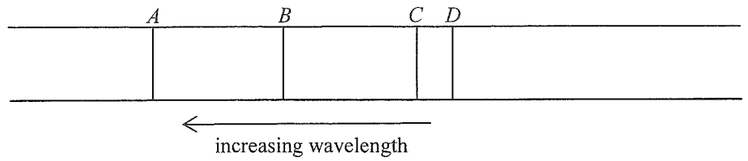
Please stick the barcode label here.

Q.2: Structured question

(a) Rutherford's planetary model of the atom failed to account for the stability of atoms. Why ? (1 mark)

(b) The emission spectrum of hydrogen atoms only has four visible spectral lines (*A* to *D*) as shown in Figure 2.1.

Figure 2.1



All these lines belong to a series that corresponds to transitions to the first excited state ($n = 2$). In this series there are no spectral lines beyond *A*. The wavelengths λ (in nm) of all the spectral lines in the series are given empirically by the formula below.

$$\lambda = 364.6\left(\frac{n^2}{n^2 - 2^2}\right) \text{ where } n = 3, 4, 5, \cdots$$

(i) Which spectral line (*A*, *B*, *C* or *D*) comes from the electron transition between energy levels $n = 5$ and $n = 2$? (1 mark)

(ii) Find the wavelength of the spectral line in (b)(i) and state the colour of this line. (2 marks)

(iii) The remaining numerous invisible spectral lines in the series beyond line *D* are getting closer and closer until they finally converge to a limit of 364.6 nm. Suppose a photon of wavelength shorter than 364.6 nm collides with a hydrogen atom in the first excited state ($n = 2$). State what would happen to **the incident photon**, **the hydrogen atom** and **its orbital electron**. (3 marks)

(iv) Initially a group of hydrogen atoms are in the third excited state ($n = 4$). Illustrate with the aid of an energy level diagram **ALL** possible electron transitions that would produce **emission lines**. Mark a letter 'V' against the transition(s) that give(s) rise to visible spectral lines. (3 marks)

Go on to the next page

Section C : Energy and Use of Energy

Q.3: Multiple-choice questions

3.1 A light power of 1 W delivered by a green light source corresponds to a luminous flux of 683 lm. Taking into account the sensitivity of human eye, a light power of 1 W delivered by a filament lamp emitting white light only gives about half of this luminous flux. If the end-use energy efficiency of the filament lamp is about 3%, estimate its efficacy.

A. 40 lm W^{-1}
B. 20 lm W^{-1}
C. 10 lm W^{-1}
D. 5 lm W^{-1}

A ○ B ○ C ○ D ○

3.2 A wind turbine generator can extract energy from moving air. However, the kinetic energy of wind cannot be fully transformed into electrical energy because

(1) wind velocity cannot be zero after passing through the turbine.
(2) there is loss in transformation of energy in the generator.
(3) wind may not always blow in the direction normal to the turbine.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

A ○ B ○ C ○ D ○

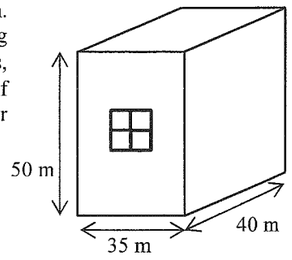
3.3 Even on a clear day, the atmosphere absorbs at least 26.8% of solar power. Find the maximum power output of a solar panel of area 5 m^2 which has an efficiency of 15%. Given: solar constant = 1366 W m^{-2}

A. 275 W
B. 750 W
C. 1560 W
D. 4250 W

A ○ B ○ C ○ D ○

3.4 The figure shows a concrete building of dimensions 35 m × 40 m × 50 m. It is given that the Overall Thermal Transfer Value (OTTV) of a building should not exceed 24 W m^{-2}. Find the maximum number of windows, each of size 2 m × 3 m, that can be installed on the walls of the building if the equivalent temperature difference between the interior and the exterior of the building is 10 °C.

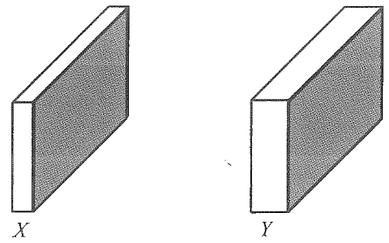
Given: U-value of the concrete of the building = 2.0 W m^{-2} K^{-1}
U-value of the glass of the windows = 5.7 W m^{-2} K^{-1}



A. 960
B. 598
C. 160
D. 120

A ○ B ○ C ○ D ○

3.5



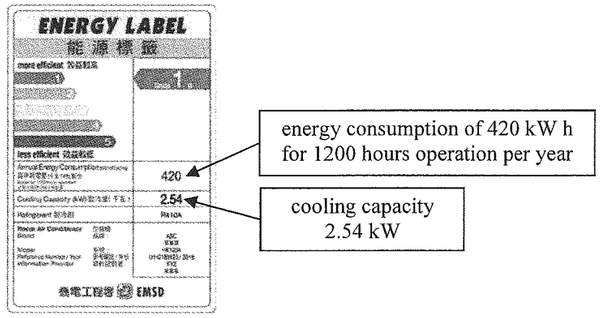
Walls *X* and *Y* having the same area are made of the same material, with *Y* thicker than *X*. If the temperature difference between the two faces of each wall is the same, *X* and *Y* have the same

(1) thermal conductivity.
(2) thermal transmittance (U-value).
(3) rate of heat transfer by conduction.

A. (1) only
B. (3) only
C. (1) and (2) only
D. (2) and (3) only

A ○ B ○ C ○ D ○

3.6 The energy label below indicates the information of a certain air-conditioner.



Find the COP (coefficient of performance) of this air-conditioner.

A. 1.12
B. 1.38
C. 7.26
D. 8.89

A ○ B ○ C ○ D ○

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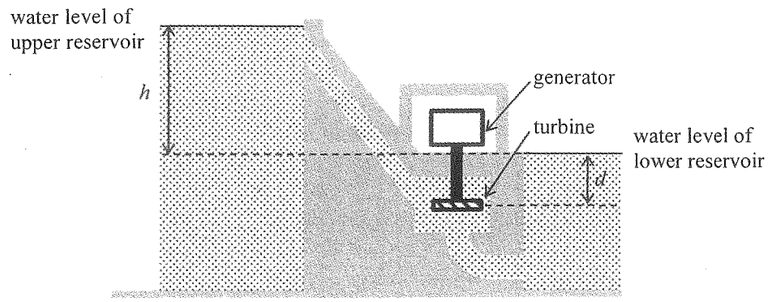
3.7 The figure below shows a hydroelectric power plant.



Which factors below can affect the maximum power output of the plant ?

(1) The height difference between the water levels in the upper and lower reservoirs, h.
(2) The distance between the turbine and the water level of the lower reservoir, d.
(3) The rate of water flowing through the turbine.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

A	B	C	D
○	○	○	○

3.8 For the fission reaction of a U-235 nucleus shown below, the mass defect is 0.1855u.

$$^{235}_{92}\mathrm{U} + {}^{1}_{0}\mathrm{n} \rightarrow {}^{94}_{40}\mathrm{Zr} + {}^{139}_{52}\mathrm{Te} + 3{}^{1}_{0}\mathrm{n}$$

How much energy (in J) would be produced when 1 kg of U-235 completely undergoes such fission ?
Given: molar mass of U-235 = 235 g
1.49×10^{-10} J of energy is released for a mass defect of 1 u

A. $\frac{1000}{235} \times 6.02 \times 10^{23} \times 0.1855 \times 1.49 \times 10^{-10}$
B. $\frac{1}{235} \times 6.02 \times 10^{23} \times 0.1855 \times 1.49 \times 10^{-10}$
C. $\frac{235}{1000} \times 6.02 \times 10^{23} \times 0.1855 \times 1.49 \times 10^{-10}$
D. $\frac{1000}{235} \times 6.02 \times 10^{23} \times 1.49 \times 10^{-10}$

A	B	C	D
○	○	○	○

Q.3: Structured question

Some information of electric vehicles *A* and *B* is tabulated below:

electric vehicle	battery capacity / kW h	maximum driving range / km	mass / kg
A	95	326	2500
B	66	414	1620

(a) Although the battery capacity of *A* is higher, its maximum driving range is shorter than that of *B*. State a possible reason and explain why. (1 mark)

(b) (i) Suppose a charging voltage of 220 V is provided, estimate the minimum charging current required for charging the battery of vehicle *A* from completely discharged to fully charged in 12 hours. (2 marks)

(ii) Explain why in practice the charging current required is larger than that found in (b)(i). (1 mark)

The table below shows more information about the electric vehicles:

electric vehicle	time required to accelerate from 0 to 100 km h^{-1} / s	peak power / kW
A	5.5	300
B	6.5	150

(c) Referring to all the information given, estimate

(i) the energy efficiency of vehicle *A*. You may assume that the vehicle is operating at its peak power. (2 marks)

(ii) the average output power from the battery of vehicle *B* if its average speed is 70 km h^{-1} in the maximum driving range test. (2 marks)

(d) Discuss in which of the driving modes below the regenerative braking system has the highest effectiveness: (2 marks)

Mode 1	driving at a few km per hour in often stop-and-go traffic conditions
Mode 2	driving in a city with smooth traffic regulated by traffic lights
Mode 3	driving on a highway

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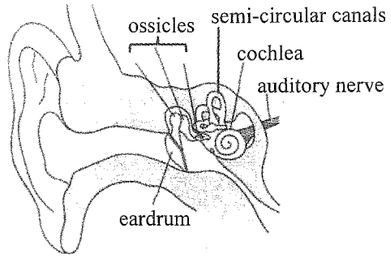
Section D : Medical Physics

Q.4: Multiple-choice questions

4.1 Which part of the ear discerns frequency ?



A. eardrum
B. semi-circular canals
C. ossicles
D. cochlea

A B C D
○ ○ ○ ○

4.2 Each optical fibre in an endoscope consists of a core enclosed by a cladding. The core and the cladding are made of two different transparent materials. Which descriptions about an optical fibre are correct ?

(1) The refractive index of the cladding is smaller than that of the core.
(2) The core-cladding boundary gives a smaller critical angle compared to a core-air boundary.
(3) Without cladding, some of the light rays would pass between optical fibres at points of contact.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

A B C D
○ ○ ○ ○

4.3 Which descriptions about A-scan and B-scan of ultrasound imaging are correct ?

(1) B-scan is more useful for locating tumours.
(2) B-scan is employed for viewing the movement of an organ in real time.
(3) B-scan has a higher resolution.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

A B C D
○ ○ ○ ○

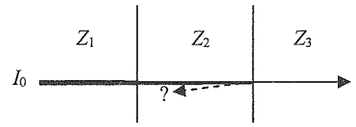
4.4 When diagnosing brain injuries, doctors use computed tomography (CT) scans to locate positions of internal bleeding. With reference to this context, which reasons given below for **NOT** using the respective imaging methods are correct ?

(1) X-ray radiography: due to its insufficient resolution.
(2) Ultrasound scanning: as ultrasound cannot penetrate through the skull.
(3) Endoscopy: as there is no cavity in the brain for inserting an endoscope.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

A B C D
○ ○ ○ ○

4.5 A narrow beam of ultrasound of intensity I_0 travels through three media of different acoustic impedances Z_1, Z_2 and Z_3 as shown.



Assume that attenuation and absorption of ultrasound are negligible. What is the intensity of the ultrasound reflected from the interface between the media of acoustic impedances Z_2 and Z_3 ?

A. $\left[1-\frac{(Z_2-Z_1)^2}{(Z_2+Z_1)^2}\right]\frac{(Z_3-Z_2)^2}{(Z_3+Z_2)^2}\,I_0$

B. $\frac{(Z_2-Z_1)^2}{(Z_2+Z_1)^2}\frac{(Z_3-Z_2)^2}{(Z_3+Z_2)^2}\,I_0$

C. $\frac{(Z_2-Z_1)^2}{(Z_2+Z_1)^2}\left[1-\frac{(Z_3-Z_2)^2}{(Z_3+Z_2)^2}\right]I_0$

D. $\left[1-\frac{(Z_2-Z_1)^2}{(Z_2+Z_1)^2}\right]\left[1-\frac{(Z_3-Z_2)^2}{(Z_3+Z_2)^2}\right]I_0$

A B C D
○ ○ ○ ○

4.6 The intensity of an X-ray beam is decreased by 25% after passing through a metal plate of thickness 0.01 m. Find the corresponding half-value thickness for this X-ray beam.

A. 0.005 m
B. 0.020 m
C. 0.024 m
D. 0.042 m

A B C D
○ ○ ○ ○

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4.7 Radionuclide imaging uses only γ radiations as

(1) γ can be deflected by a magnetic field to incident on the patient at any angle.
(2) γ has low ionizing power and causes less harm to cells.
(3) γ has high penetrating power and is detectable outside the body.

A. (1) only
B. (3) only
C. (1) and (2) only
D. (2) and (3) only

A ○ B ○ C ○ D ○

4.8 The radiation weighting factor of different radiations for calculating the effective dose are listed below:

α radiation	20
β radiation	1
γ radiation	1
X-rays	1

α is given a much larger radiation weighting factor because it

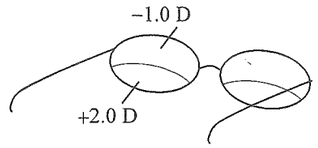
A. has a low penetrating power.
B. has a strong ionizing power.
C. has a relatively larger mass since it is a helium nucleus.
D. is particle in nature.

A ○ B ○ C ○ D ○

Q.4: Structured question

(a) Roger is suffering from eye defects and he has to wear the spectacles shown in Figure 4.1. The upper and lower halves of each lens are of powers −1.0 D and +2.0 D respectively.

Figure 4.1

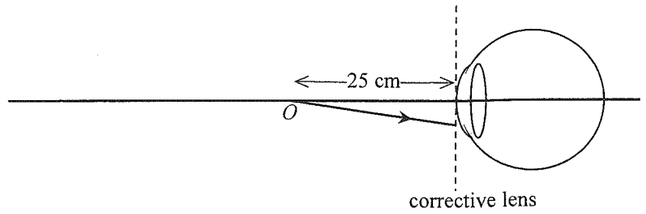


With the spectacles, Roger's near point can be corrected to 25 cm from his eyes while his far point is corrected to infinity. Assume that the lenses are very close to his eyes.

(i) State which half of the lens enables Roger to see distant objects clearly. Find the far point distance of his unaided eyes. (2 marks)

(ii) Figure 4.2 shows a point object O placed at 25 cm in front of the corrective lens which is represented by a dotted line.

Figure 4.2

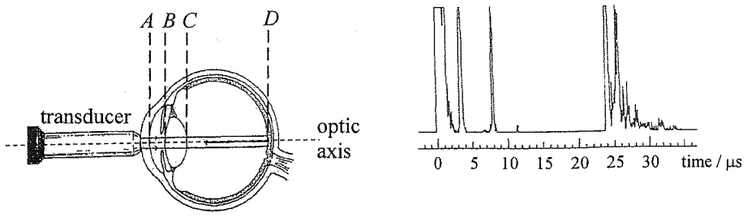


(1) **Copy Figure 4.2 to your answer book** and complete the path of the ray from O to show how it reaches the retina. Indicate the near point N of Roger's unaided eyes in your diagram. Assume that refraction in the eye is due to the eye lens only. (2 marks)

(2) Calculate the distance of N from his eyes. (2 marks)

(b) An ultrasound transducer is used to scan an eye as shown in Figure 4.3. The pulses reflected from interfaces A, B, C and D are recorded in the A-scan display below.

Figure 4.3



(i) Estimate the thickness of the eye lens along the optic axis.
Given: velocity of ultrasound in the eye lens = 1520 m s^{-1}. (2 marks)

(ii) Explain which frequency of ultrasound, 3 MHz or 15 MHz, is preferred for scanning the eye. (1 mark)

(iii) Apart from forming images in a diagnostic scan, name **ONE** medical application of ultrasound. (1 mark)

END OF PAPER

Sources of materials used in this paper will be acknowledged in the *HKDSE Question Papers* booklet published by the Hong Kong Examinations and Assessment Authority at a later stage.

List of data, formulae and relationships

Data

molar gas constant	$R = 8.31$ J mol^{-1} K^{-1}
Avogadro constant	$N_A = 6.02 \times 10^{23}$ mol^{-1}
acceleration due to gravity	$g = 9.81$ m s^{-2} (close to the Earth)
universal gravitational constant	$G = 6.67 \times 10^{-11}$ N m^2 kg^{-2}
speed of light in vacuum	$c = 3.00 \times 10^8$ m s^{-1}
charge of electron	$q_e = 1.60 \times 10^{-19}$ C
electron rest mass	$m_e = 9.11 \times 10^{-31}$ kg
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}$ C^2 N^{-1} m^{-2}
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}$ H m^{-1}
atomic mass unit	u = 1.661×10^{-27} kg (1 u is equivalent to 931 MeV)
astronomical unit	AU = 1.50×10^{11} m
light year	ly = 9.46×10^{15} m
parsec	pc = 3.09×10^{16} m = 3.26 ly = 206265 AU
Stefan constant	$\sigma = 5.67 \times 10^{-8}$ W m^{-2} K^{-4}
Planck constant	$h = 6.63 \times 10^{-34}$ J s

Rectilinear motion

For uniformly accelerated motion :

$$v = u + at$$
$$s = ut + \frac{1}{2}at^2$$
$$v^2 = u^2 + 2as$$

Mathematics

Equation of a straight line	$y = mx + c$
Arc length	$= r\theta$
Surface area of cylinder	$= 2\pi rh + 2\pi r^2$
Volume of cylinder	$= \pi r^2 h$
Surface area of sphere	$= 4\pi r^2$
Volume of sphere	$= \frac{4}{3}\pi r^3$

For small angles, $\sin\theta \approx \tan\theta \approx \theta$ (in radians)

Astronomy and Space Science

$U = -\frac{GMm}{r}$	gravitational potential energy
$P = \sigma AT^4$	Stefan's law
$\left\|\frac{\Delta f}{f_0}\right\| \approx \frac{v}{c} \approx \left\|\frac{\Delta\lambda}{\lambda_0}\right\|$	Doppler effect

Atomic World

$\frac{1}{2}m_e v_{max}^{\ 2} = hf - \phi$	Einstein's photoelectric equation
$E_n = -\frac{1}{n^2}\left\{\frac{m_e q_e^4}{8h^2\varepsilon_0^2}\right\} = -\frac{13.6}{n^2}$ eV	energy level equation for hydrogen atom
$\lambda = \frac{h}{p} = \frac{h}{mv}$	de Broglie formula
$\theta \approx \frac{1.22\lambda}{d}$	Rayleigh criterion (resolving power)

Energy and Use of Energy

$E = \frac{\Phi}{A}$	illuminance
$\frac{Q}{t} = \kappa\frac{A(T_H - T_C)}{d}$	rate of energy transfer by conduction
$U = \frac{\kappa}{d}$	thermal transmittance U-value
$P = \frac{1}{2}\rho Av^3$	maximum power by wind turbine

Medical Physics

$\theta \approx \frac{1.22\lambda}{d}$	Rayleigh criterion (resolving power)
power $= \frac{1}{f}$	power of a lens
$L = 10\log\frac{I}{I_0}$	intensity level (dB)
$Z = \rho c$	acoustic impedance
$\alpha = \frac{I_r}{I_0} = \frac{(Z_2 - Z_1)^2}{(Z_2 + Z_1)^2}$	intensity reflection coefficient
$I = I_0 e^{-\mu x}$	transmitted intensity through a medium

A1.	$E = mc\,\Delta T$	energy transfer during heating and cooling	D1.	$F = \frac{Q_1 Q_2}{4\pi\varepsilon_0 r^2}$	Coulomb's law
A2.	$E = l\,\Delta m$	energy transfer during change of state	D2.	$E = \frac{Q}{4\pi\varepsilon_0 r^2}$	electric field strength due to a point charge
A3.	$pV = nRT$	equation of state for an ideal gas	D3.	$E = \frac{V}{d}$	electric field between parallel plates (numerically)
A4.	$pV = \frac{1}{3}Nm\overline{c^2}$	kinetic theory equation	D4.	$R = \frac{\rho l}{A}$	resistance and resistivity
A5.	$E_K = \frac{3RT}{2N_A}$	molecular kinetic energy	D5.	$R = R_1 + R_2$	resistors in series
			D6.	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$	resistors in parallel
B1.	$F = m\frac{\Delta v}{\Delta t} = \frac{\Delta p}{\Delta t}$	force	D7.	$P = IV = I^2R$	power in a circuit
B2.	moment $= F \times d$	moment of a force	D8.	$F = BQv\sin\theta$	force on a moving charge in a magnetic field
B3.	$E_P = mgh$	gravitational potential energy	D9.	$F = BIl\sin\theta$	force on a current-carrying conductor in a magnetic field
B4.	$E_K = \frac{1}{2}mv^2$	kinetic energy	D10.	$B = \frac{\mu_0 I}{2\pi r}$	magnetic field due to a long straight wire
B5.	$P = Fv$	mechanical power	D11.	$B = \frac{\mu_0 NI}{l}$	magnetic field inside a long solenoid
B6.	$a = \frac{v^2}{r} = \omega^2 r$	centripetal acceleration	D12.	$\varepsilon = N\frac{\Delta\Phi}{\Delta t}$	induced e.m.f.
B7.	$F = \frac{Gm_1m_2}{r^2}$	Newton's law of gravitation	D13.	$\frac{V_s}{V_p} \approx \frac{N_s}{N_p}$	ratio of secondary voltage to primary voltage in a transformer

C1.	$\Delta y = \frac{\lambda D}{a}$	fringe separation in double-slit interference	E1.	$N = N_0 e^{-kt}$	law of radioactive decay
C2.	$d\sin\theta = n\lambda$	diffraction grating equation	E2.	$t_{\frac{1}{2}} = \frac{\ln 2}{k}$	half-life and decay constant
C3.	$\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$	equation for a single lens	E3.	$A = kN$	activity and the number of undecayed nuclei
			E4.	$\Delta E = \Delta mc^2$	mass-energy relationship