2020 HKDSE Physics & Combined Science (Physics)

Report on Assessment

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7 & 8 Oct 2020

Overview

Paper	Physics	CS(Phy)
1A (MC)	Mean: 17.5 out of 33 (i.e. 53%) (2019: 19.2 out of 33)	Mean: 8.9 out of 22 (i.e. 40%) (2019: 9.8 out of 22)
1B	~50% (2019: ~>50%)	~35% (2019: 35%~40%)
2	~<50% (2019: ~>50%)	N.A.
SBA	~>70% (~2019)	~<70% (~2019)
Candidature	ALL: 10692 SCH: 9 866	ALL: 272 SCH: 252

Marking & Grading

On-Screen Marking (OSM) panels	
Physics	**CS(Phy)**
1B-1: Q.1, 3, 4, 5 (32M) 1B-2: Q.6, 7, 8 (26M) 1B-3: Q.2, 9, 10 (26M)	1B-1: Q.1, 2, 3, 4 (31M) 1B-2: Q.5, 6, 7 (25M)

2A: Astronomy (18%) 2B: Atomic World (67%) 2C: Energy (85%) 2D: Medical Physics (30%)	---

SBA marks stat. moderated (outlying cases ~10% reviewed by Supervisors)

Marking & Grading

- Expert Panel (Examiners, 4 ~ 5 persons) determine level boundaries/cut scores based on **Level descriptors / Group Ability Indicator (GAI) / Viewing candidate samples**.
- CS(Phy) graded by **Common items / Viewing candidate samples.**
- Endorsement by Senior Management/Public Exam Board

Note: GAI is generated from Physics candidates' actual percentage awards in 4 core subjects CEML taken into consideration the correlation between Physics and CEML.

Results

Physics

Cut score difference Δ = 47.4 %

Level	5**	5+	4+	3+	2+	1+
Percentage	2.6%	26.3%	48.9%	72.6%	90.1%	97.9%
No. of MC	30	23/22	18	14/13	10	7

CS(Phy)

Cut score difference Δ = 42.4 %

Level	5**	5+	4+	3+	2+	1+
Percentage	0.5%	5.0%	10.9%	35.8%	68.3%	88.1%
No. of MC	17	15	14/13	10	8	6

Paper 1A

Physics (33 MC)

>70%	50%-70%	<50%
4	16	13

Easy ⟷ Difficult

CS (Phy) (22 MC)

>70%	50%-70%	<50%
2	3	17

Easy ⟷ Difficult

PHYSICS MC

Topic (No. of Qu.)	Average % correct	No. of Qu. < 50% correct
Heat & Gases (3)	58%	0
Force & Motion (7)	59%	1
Wave Motion (11)	52%	6
Electricity & Magnetism (8)	48%	4
Radioactivity (4)	51%	2

CS(PHY) MC

Topic (No. of Qu.)	Average % correct	No. of Qu. < 50% correct
Heat & Gases (2)	48%	1
Force & Motion (4)	47%	3
Wave Motion (9)	40%	7
Electricity & Magnetism (7)	36%	6

5.

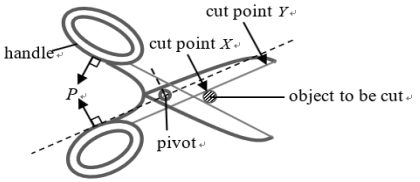
For a car travelling on a highway, which of the following statements about the safety design of the headrest is/are correct ?

(1) As the headrest is soft, it can reduce the force exerted on the passenger's head during impact.
(2) It can minimise injury of the passenger when the car is struck by another one from behind.
(3) It can minimise injury of the passenger when the car brakes suddenly.

			Phy	CS(Phy)
A.	(1) only	favourable distractor	(25%)	(31%)
B.	(3) only		(10%)	(11%)
* C.	(1) and (2) only		(52%)	(42%)
D.	(2) and (3) only		(13%)	(16%)

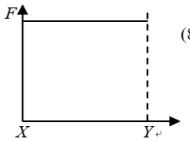
Over one-third of the candidates did not think that statement (2) could be correct.

7. The figure shows that a pair of forces P of constant magnitude is applied at right angles to the handles of a pair of scissors in order to cut an object.

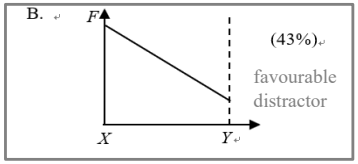


Which graph below best shows the variation of force F produced at cut point from X to Y when the pair of scissors is closed ?

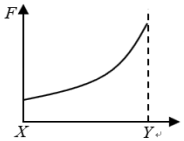
A. (8%)



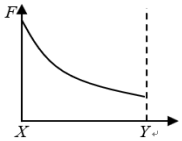
B. (43%) favourable distractor



C. (20%)

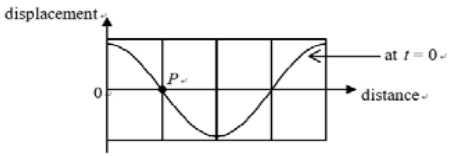


*D. (29%)



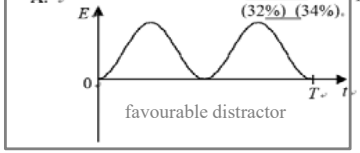
While over 70% of the candidates indicated knowledge that the force is larger at cut point X, less than 30% of them fully understood how the force varies when the pair of scissors is closed.

12. The figure shows part of the displacement-distance graph of a travelling wave of period T at time $t = 0$. P is a particle on the wave.

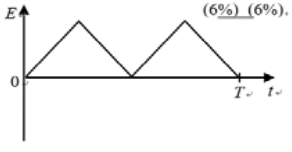


Which graph below correctly shows the variation of the particle's kinetic energy E within a period starting from $t = 0$?

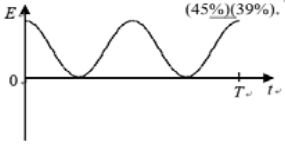
A. Phy CS(Phy) (32%) (34%) favourable distractor



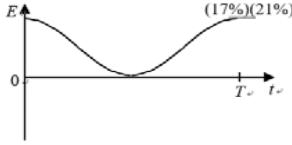
B. Phy CS(Phy) (6%) (6%)



*C. (45%)(39%)



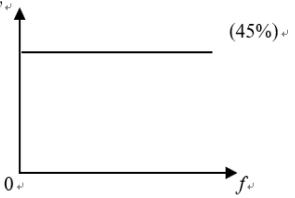
D. (17%)(21%)



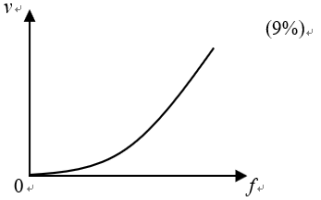
Less than half of the candidates were able to obtain the correct answer of which the particle's kinetic energy is at a maximum at $t = 0$.

16. A transverse wave propagates along a stretched string. Which graph below correctly shows the variation of the speed v of the wave with its frequency f?

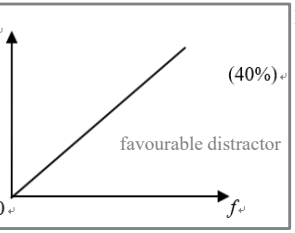
*A. (45%)



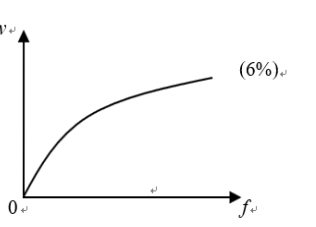
B. (9%)



C. (40%) favourable distractor

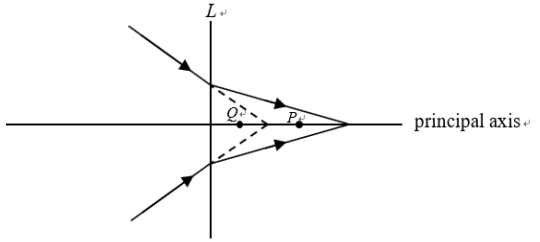


D. (6%)



40% of the candidates thought that the speed v increases linearly with frequency f and chose option C, which suggests that some candidates might have assumed the wavelength, instead of the speed, remains unchanged on a stretched string.

18.



Referring to the above ray diagram, what kind of lens is represented by *L* ? Which point, *P* or *Q*, can be its focus ?

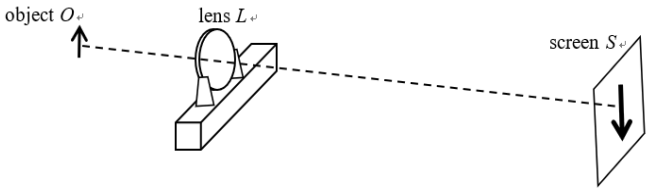
	lens *L*	focus	Phy	CS(Phy)
*A.	concave	*P*	(45%)	(26%)
B.	convex	*P*	(22%)	(33%)
C.	concave	*Q*	(20%)	(24%)
D.	convex	*Q*	(13%)	(17%)

favourable distractor

Candidates choosing options B and D suggests that they did not have a basic understanding of the converging and diverging properties of lenses.

13

20. The figure shows an enlarged sharp image of an object *O* formed on a screen *S* by a convex lens *L*.



Which of the following can give a diminished sharp image on the screen ?

(1) Keeping the positions of *O* and *L* unchanged, move *S* suitably closer to *L*.
(2) Keeping the positions of *L* and *S* unchanged, move *O* suitably farther away from *L*.
(3) Keeping the positions of *O* and *S* unchanged, move *L* suitably closer to *S*.

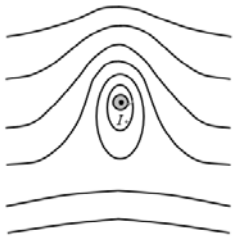
		Phy	CS(Phy)
A.	(1) only	(13%)	(21%)
*B.	(3) only	(31%)	(23%)
C.	(1) and (2) only	(14%)	(30%)
D.	(2) and (3) only	(42%)	(26%)

favourable distractor

Less than one-third of the candidates were able to answer this question correctly. It seems that many candidates were not aware that a certain object distance only corresponds to a unique image distance.

14

26. The figure below shows the magnetic field pattern on a horizontal surface around a long vertical straight wire carrying a steady current *I* pointing out of the paper. The Earth's magnetic field is **NOT** neglected.



Top view

What are the directions of the following ?

	the horizontal component of the Earth's magnetic field	the magnetic force experienced by the current-carrying wire	Phy	CS(Phy)
*A.	←	↓	(42%)	(23%)
B.	←	↑	(25%)	(34%)
C.	→	↓	(13%)	(21%)
D.	→	↑	(20%)	(22%)

favourable distractor

Of the two-thirds of the candidates correctly identifying the direction of the magnetic field, just over 40% were also able to get the direction of magnetic force correct.

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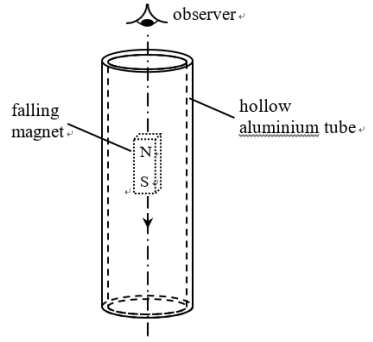
28.



When a small strong magnet falls through a hollow aluminium tube as shown, eddy currents are induced. Which of the following correctly describes the direction of current induced in the tube when viewed by an observer from above ?

		Phy	CS(Phy)
A.	clockwise both above and below the magnet	(17%)	(23%)
B.	anti-clockwise both above and below the magnet	(19%)	(20%)
C.	clockwise above the magnet and anti-clockwise below the magnet	(32%)	(28%)
*D.	anti-clockwise above the magnet and clockwise below the magnet	(32%)	(29%)

favourable distractor

Only one-third of the candidates were able to apply Lenz's law in answering this problem.

16

32. The decay constant of a radioisotope of an element

A.	is random.	favourable distractor	(22%)
B.	depends on pressure and temperature.		(8%)
C.	is directly proportional to the number of nucleons in the isotope.		(21%)
*D.	is an identifying characteristic of that isotope.		(49%)

Just under half of the candidates fully understood the uniqueness of decay constant.

17

Observations

- Strength:
- competent in calculations
- most simple questions answered well
- Weakness:
- weak in handling units
- qualitative responses far from precise
- not paying attention to details when drawing diagrams
- weak in handling experimental type questions

18

Points to note

- Paper 1: ~70% core part
- Method marks 'M' and Answer marks 'A' (with tolerance range) adopted.
- Accept BOTH g = 9.81 or 10 m s^{-2}.

19

Points to note

- Electives (Total = 80 each) equating using Paper 1

Before equating: Mean 32 to 37 / SD 17 to 22
After equating: Mean 36 to 42 / SD 17 to 19

2A Astronomy: ~ unchanged
2B Atomic World: ↑↑
2C Energy: ↑
2D Medical Physics: ~ unchanged

20

Points to note

- Samples of performance of candidates available in late October (HKEAA website).
- SBA cancelled for DSE Phy 2021
- 2021 DSE Phy Exam on 5 May 2021

Markers' Mtg:	Paper 1B	11/5
(tentative)	Paper 2	10/5

THANK YOU

HKDSE PHYSICS SEMINAR

DSE PHYSICS 1B – Q 1, 3, 4, 5

1. In a restaurant, 'wontons in soup' is prepared by putting 5 pieces of cooked wonton at 4 °C into a bowl with 0.60 kg of soup at temperature 96 °C.

   Given: average mass of each piece of wonton = 0.02 kg
   specific heat capacity of wonton = 3300 J kg^{-1} $°C^{-1}$
   specific heat capacity of soup = 4200 J kg^{-1} $°C^{-1}$

   (a) Find the final temperature of the mixture. Assume that the heat capacity of the bowl and the heat loss to the surroundings are negligible. (2 marks)

Suggested Solutions	Students' Responses
$5 \times 0.02 \times 3300 \times (T - 4)$ $= 0.60 \times 4200 \times (96 - T)$ $T = 85.347368\ °C \approx 85.3\ °C$	Let T be the final temperature $5 \times 0.02 \times 3300 \times (T-4) = 0.6 \times 4200 \times (96-T)$ ✓ $330T - 1320 = 241920 - 2520T$ $2850T = 243240$ ✓ 2 $T = 85.3°C$. (3SF)

Students' Responses

$mc_1\Delta T = m_1c_2\Delta T$

$0.02\times5\times3300\times(96-T) = 0.06\times4200\times(T-4)$ ✗

$31680 - 330T = 252T - 1008$ 0

$T \approx 56.2\,^\circ C$ ✗

$0.02\times5\times3300\times(T-4) = 0.06\times4200\times(96-T)$ ✓

$330T - 1320 = 24192 - 252T$

$582T = 25512$ 1

$T = 43.8\,^\circ C$ ✗

没单位温度为R Missing '5'

$E=mc\Delta T$

$0.6(4200)(96-R) = 0.02(3300)(R-4)$ ✓

$2520(96-R) = 66(R-4)$

$241920 - 2520R = 66R - 264$

$242184 = 2586R$ 1

$R = 93.6^\circ$ ✗

(b) The soup in (a) is taken from a metallic container of heat capacity 2000 J $°C^{-1}$ containing 16 kg of soup maintained at 96 °C by an immersion heater.

(i) Why does that energy have to be supplied by the heater to keep the soup at 96 °C ? (1 mark)

Suggested Solutions	Students' Responses
To compensate for / balance the heat loss (of the container with soup) to the surroundings	As the soup have heat loss to ✓ surrounding. 1 So energy have to be supplied to keep the soup at 96°C Because heat loss to the surrounding ✓ 1 Since it has to replenish the energy of soup which lose to the heat capacity of metallic container ✗ 0

1(b)(ii) A student used the following method to find the heater's operating power *P*: remove the heater from the container and record the temperature of the 16 kg of soup after 10 minutes. It is found that the temperature has dropped 9 °C. Estimate *P*. (3 marks)

Suggested Solutions	Students' Responses
$P \times 10 \times 60$ $= 2000 \times 9 + 16 \times 4200 \times 9$ $P = 1038$ W ≈ 1040 W	$Pt = m_1c_1\Delta t + m_2c_2\Delta t$ ✓ ✓ $P(10\times60) = 16\times4200\times9 + 2000\times9$ $P = 1038$ W ✓ 3 $Pt = mc\Delta T$ $P\times10\times60 = 16\times4200\times9$ ✓ 1 $P = 1008$ W ✗ $Pt = mc\Delta T$ ✓ $P(10\times60) = 16(4200)(96-9)$ 1 $P = 97447$ ✗

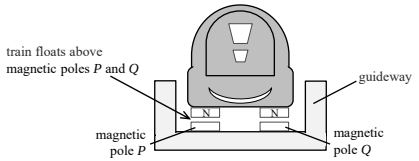
1(b)(iii) If the student repeats the measurement after another 10 minutes, would the corresponding temperature drop be larger than, equal to or smaller than 9 °C ? Explain. (2 marks)

Suggested Solutions	Students' Responses
Smaller than 9 °C. As the temperature of (the container with) soup drops, the rate of heat loss to the surroundings becomes lower due to a *smaller temperature difference* (w.r.t. the surroundings)	The temperature drop will be smaller ✓ than 9°C Since the temperature difference between the soup and the room temperature become ✓ smaller, thus the rate of heat loss reduce. ✓ 2 The drop in ~~Smaller than~~ Smaller than 9°C. temperature would be ✓ Because the temperature of the soup ~~is~~ is being closer to ~~the~~ the room temperature. ✓ Therefore, the drop in temperature is in a decreasing rate. 2 the corresponding temperature will be smaller ✓ than 9°C as ✗ the power need to heat the metallic container 1 as well

3. Read the following passage about a magnetically levitated (maglev) train and answer the questions that follow.

'A maglev train car is just a box with magnets on the four corners,' says Jesse Powell, the son of the maglev train inventor. The electromagnets employed have superconducting coils (i.e. coils with extremely low resistance). They therefore can generate magnetic fields 10 times stronger than ordinary electromagnets, enough to levitate and propel a train.

Two sets of magnetic fields are set up for different functions. One is to make the train float a few centimetres above magnetic poles P and Q as shown while the other is a propulsion system run by an alternating current for moving the train car along the guideway by magnetic attraction and repulsion. This floating design enables a smooth movement of the train. Even when the train travels up to 600 km per hour, passengers inside experience less vibration than travelling on traditional trains.



LEVITATION

(a) Explain why electromagnets employing superconducting coils can produce much stronger magnetic fields. (2 marks)

Suggested Solutions	Students' Responses
With superconductor / extremely *low or nearly zero resistance*, a much *larger current* flows in the coils producing a stronger magnetic field (with less heat loss due to the current flow).	Since the superconducting coils have extremely low resistance, by $V=IR$, the current it generates is extremely large ✓ ✓, therefore, as magnetic field is directly proportional to the magnitude of current, the magnetic field is stronger. 2 As after employing superconducting coils, more ✓ current can flow through the wire when the magnitude of current increases, by $B=\frac{\mu_0 I}{2\pi r}$, the magnetic fields will also increase. 1 As it only has extremely low resistance. With lower resistance, there will be more energy so that it can produce stronger magnetic fields. 0 ✗

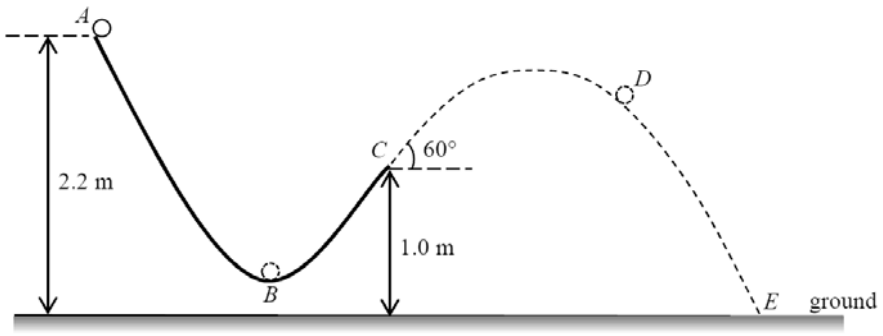
(b) State the polarities of the magnetic poles *P* and *Q* and explain how this arrangement enables the train to float. (2 marks)

Suggested Solutions	Students' Responses
P and *Q* : N (north pole) Repulsive force between like poles	The polarities of P and Q are N-pole. ✓ So repulsion force is resulted such that the poles repel ✓ and, train is pushed to move forward and float in air. 2 P及Q的磁性與列車下的磁鐵是同性相斥，運用這個原理使列車能夠懸浮。 ✓ 1 極P、Q磁性為正，与列车下的磁极相斥，使對列车因为磁极相斥而浮在空中。 ✓ 1 the polarities = South. ✗ 0 These polarites provide a repulsive force to the N-pole so that the train can float.

(c) Referring to the resistive forces experienced by the train, explain why a maglev train ride is (i) smoother and (ii) faster. (2 marks)

Suggested Solutions	Students' Responses
(i) As the train is not in contact with the rail, there is no friction / interaction between the train and the rail, thus smoother due to less vibration. (ii) There is no friction / interaction between the train and the rail, and the propulsion of the train only *needs to work against air resistance*, therefore much faster	On a normal train, the train experience both friction from the rail and air resistance, while mayley trains float above its rails and hence only experience ✓ air resistance. It is not subjects to the ✓ resistive force from the rail and hence can have a larger net force driving it forward. And hence the ride is smoother and faster. 2 (i) As the train does not contact with the guideway, no ✓ friction will be produced, and hence the train ride without friction from making the ride not smooth. 1 (ii) As no resistive forces is exerted to the train to hinder its movement, the ride will be fast.

4. A small sphere is released from rest at point *A* and runs along a smooth track *ABC* as shown in Figure 4.1. The track around the lowest point *B* is approximately circular in shape.



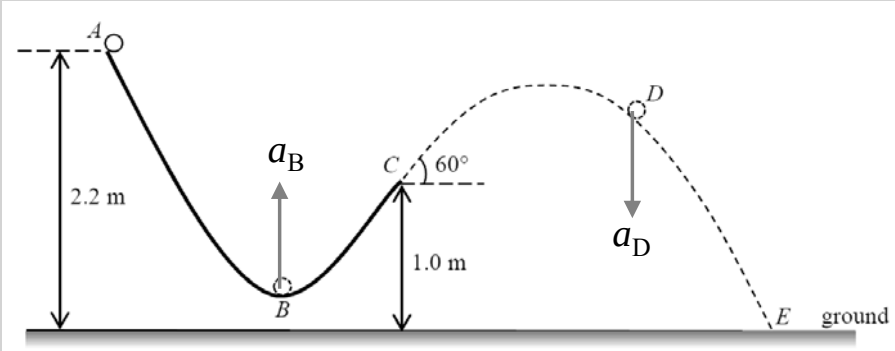
The sphere leaves the track at point C where the track makes an angle of 60° with the horizontal. It finally reaches point E on the ground. Neglect air resistance. ($g = 9.81$ m s^{-2})

(a) Arrange the speeds of the sphere at points *A*, *B*, *C* and *D* respectively in descending order. (1 mark)

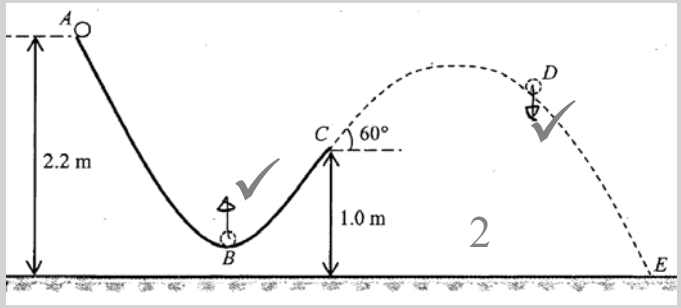
Suggested Solutions	Students' Responses
$v_B > v_C > v_D > v_A$	speed at B > speed at C > speed at D > speed at A ✓ 1 B > C > D > A ✓ 1 B, C, D, A ✓ 1 A < D < C < B ✓ 1

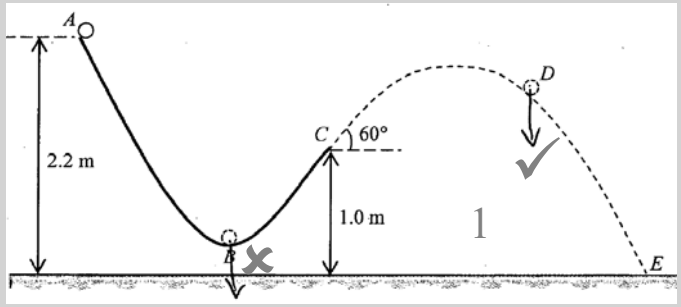
*(b) On Figure 4.1, use arrows to indicate the acceleration of the sphere, if any, at point *B* and at point *D* respectively. (2 marks)

Suggested solution

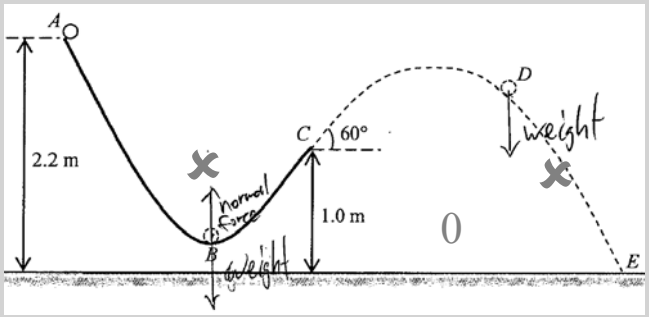


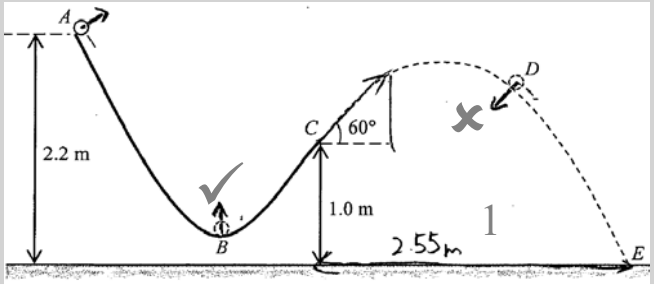
Students' Responses





Students' Responses





(c) (i) Describe the energy conversion of the sphere when it goes along the track *ABC*. (2 marks)

Suggested Solutions	Students' Responses
Gravitational potential energy is changed to kinetic energy from *A* to *B*, and *some kinetic energy* is changed back to gravitational potential energy from *B* to *C*.	From A to B, part of gravitational potential energy is converted to kinetic energy. ✓ 2 From B to C, part of kinetic energy ✓ is converted to gravitational potential energy. From A to B, potential energy ✓ is converted to kinetic energy. 1 From B to C, kinetic energy ✗ is converted to potential energy.

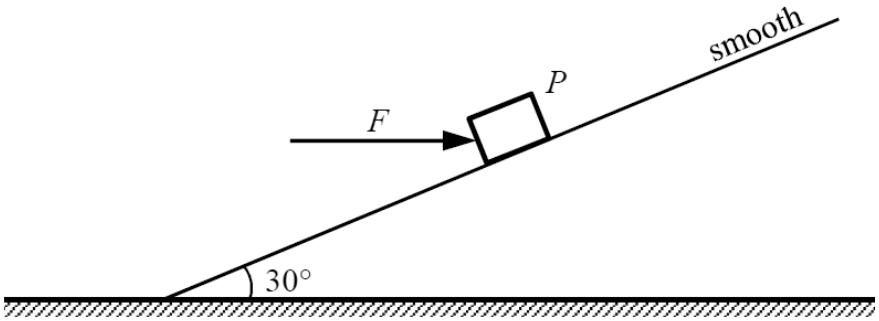
(c)(ii) Hence find the speed of the sphere at point *C*. (2 marks)

Suggested Solutions	Students' Responses
$\frac{1}{2}mv^2 = mgh$ $v^2 = 2(9.81)(2.2-1.0)$ $v = 4.85\ \text{m s}^{-1}$	Loss in G.P.E. = Gain in K.E. $mgh = \frac{1}{2}mv^2$ $\frac{1}{2}v^2 = gh$ $v = \sqrt{2 \times 9.81 \times (2.2-1)}$ ✓ $= 4.85\ \text{ms}^{-1}$ (cont 3 s.f.) ✓ 2 $v^2 = u^2 + 2as$ ✗ 0 $v^2 = 2(9.81)(2.2-1)$ $v = 4.85\ \text{ms}^{-1}$

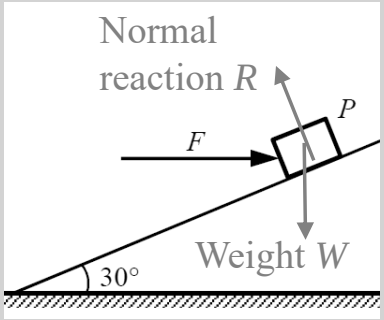
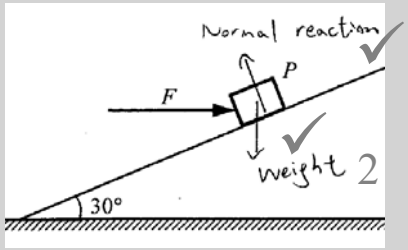
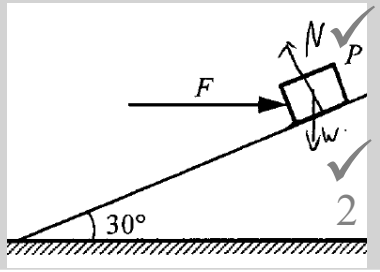
*(c)(iii) If the horizontal distance between points *C* and *E* is 2.55 m, calculate the time of flight of the sphere before reaching point *E*. (3 marks)

Suggested Solutions	Students' Responses
Horizontal speed at C $= 4.85 \times \cos 60°$ $= 2.43\ \text{m s}^{-1}$ Distance $= 2.43 \times t$ $= 2.55$ m $t = 1.05$ s	$s = vt$ $2.55 = 4.85 \cos 60° \, t$ ✓ ✓ $t = 1.05$ s ✓ 3 $-1 = 4.85 \sin 60° \, t + \frac{1}{2}(-9.81)t^2$ ✓ ✓ $t = 1.05$ s ✓ 3 ✗ $2.55 = (4.85 \sin 60°)t + \frac{1}{2}(9.81)t^2$ $t = -0.410$ s (rej.) or $t = 1.27$ s 0

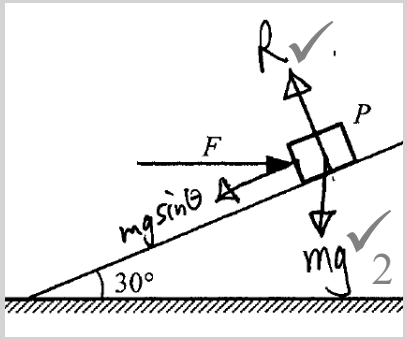
5. A block *P* of mass 10 kg is kept stationary on a smooth incline by a horizontal force *F* as shown in Figure 5.1. The incline makes an angle of 30° with the horizontal. (g = 9.81 m s^{-2})

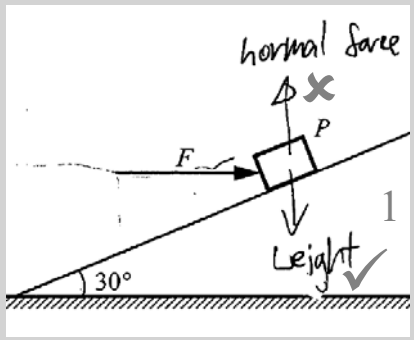


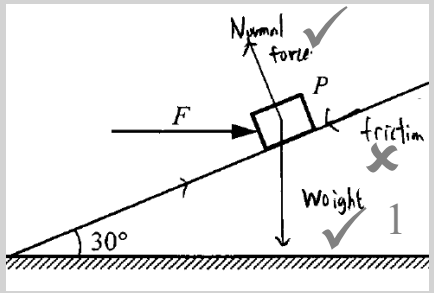
(a)(i) On Figure 5.1, indicate and label all other forces acting on *P*. (2 marks)

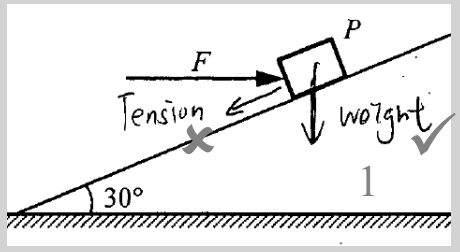
Suggested Solutions	Students' Responses
	 

Students' Responses









(a)(ii) Find the magnitudes of the force *F* and the force exerted by the block on the incline respectively. (3 marks)

Suggested Solutions	Students' Responses
$N \cos 30° = W = Mg$ and $N \sin 30° = F$ $F = Mg \times \tan 30° = 56.6$ N $R = N = \dfrac{Mg}{\cos 30°} = 113$ N Or $N = W \cos 30° + F \sin 30°$ and $W \sin 30° = F \cos 30°$	Consider vertical components of forces, $R\cos 30° = mg$ ✓ $R\cos 30° = (10)(9.81)$ $R \approx 113.3$ N ✓ Consider horizontal components of forces, $F = R\sin 30°$ ✓ $= (113.3)(\sin 30°)$ ≈ 56.7 N ✓ 3 Force exerted by the block on incline = force exerted by the incline on block ≈ 113 N $F\cos 30 = N \sin 30$ ✓ $F\cos 30 = (10)(9.81)\sin 30$ $F = 56.63$ N ✓ 3 $N = W\cos 30 + F$ ~~cos~~ $\sin 30$ ✓ $N = 10 \times 9.81 \times \cos 30 + 56.63 \sin 30$ $N = 113$ N ✓

Students' Responses

$F\cos 30° = mg\sin 30°$ ✓

$F\cos 30° = 10 \times 9.81 \times \sin 30°$

$F = 56.6\ N$ ✓ 1

Normal reaction : $mg\cos 30°$ ✗

$= 10 \times 9.81 \times \cos 30°$

$= 85.0\ N$

$mg\cos 30° = F\cos 30°$ ✗

$F = 9.81(10)$

$= 98.1\ N.$

0

$F\sin 30° + R = mg\sin 30°$ ✗

$R = 0\ N.$

(b) Now *F* is removed and neglect air resistance.

(i) What is the magnitude of the acceleration of the block ?
(1 mark)

Suggested Solutions	Students' Responses
$g\sin\theta$ $= 9.81 \sin 30°$ $= 4.91\ m\ s^{-2}$	$mg\sin\theta = ma$ $a = \frac{49.05}{10}$ ✓ $a = 4.905\ ms^{-2}$ 1 $g\sin\theta = 4.905\ N$ ✗ 0

(b)(ii) Explain whether the force exerted by the block on the incline would increase, decrease or remain unchanged when compared with that in (a)(ii). (2 marks)

Suggested Solutions	Students' Responses
Decrease as the component of *F* perpendicular to the incline no longer acts on the block / incline Or as *F* is removed, the force pressing the block / incline would decrease (only the weight's component left).	decrease ✓ In (a)(ii), there is a component force of F pointing to the incline. In (a)(ii), only the component force of W would exert on the incline. Therefore, the force would decrease. ✓ 2 Initial required force $= 10 \times 9.81\cos 30° + 56.6\sin 30° \approx 113\ N$ Final required force $= 10 \times 9.81\cos 30°$ $\approx 85.0\ N$ ✓ 2 $< 113\ N$ ∴ The required force decreases. ✓ It will remain unchanged as the is only applied horizontally. ✗ 0

Students' Responses

The force exerted by the block will ~~remain~~ ✓ decrease as F is removed, there are no ~~for~~ ~~net force~~ force acting on the incline by the block. 1

The force exerted by the block on incline will decrease. ✗ 0

The force will increase ✗ 0, as the F is removed, the new value will be $mg\cos 30°$, which is larger than (a)(ii).

THANKS

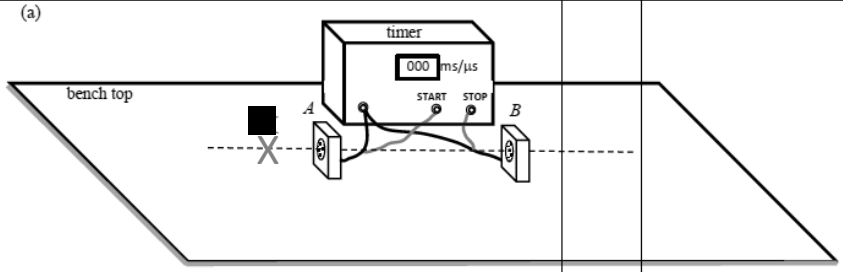
2020 HKDSE - Physics

1B-2

QUESTIONS 6, 7 & 8

6(a) You are given a hammer and a metal plate. Use 'X' to indicate a suitable location on Figure 6.1 where the hammer should hit the plate so as to generate a sharp loud sound to be received by the microphones in this experiment. State an additional piece of apparatus needed and the measurements to be made in this experiment.

6. (a)



Correct location of 'X' (close to axis and on the side of the START microphone).	1A	
Use a metre rule	1A	Accept : ruler
to measure the distance / separation D between the two microphones. Record the timer reading, which is the time interval Δt for the sound to travel from one microphone (START) to the other microphone (STOP), i.e. A to B.	1A	Any ONE of the measurements
	3	

6 (b)(i) Find the speed of sound in air. Show how you would treat the data obtained in the calculation.

(b)(ii) Suggest one adjustment to the experimental setting so as to obtain a more accurate result.

(b) (i)	Discard 539 μs, $\Delta t = \frac{801+838+821}{3} = 820$ μs The speed of sound in air $v = \frac{D}{\Delta t}$ $v = \frac{0.280}{820\times10^{-6}}$ $= 341.463415 \text{ m s}^{-1} \approx 341 \text{ m s}^{-1}$	1M 1A	1M for taking the average value of Δt and quoting the formula $v = \frac{D}{\Delta t}$ to calculate the speed of sound, where D is the separation between the microphones. Accept 340 m s^{-1} to 342 m s^{-1}
(ii)	Increase separation D between the microphones.	1A	
		3	

7(a)(i) Find i_A.

(ii) If i_A is just greater than the critical angle of that boundary, estimate $\frac{n_g}{n_c}$.

(iii) What phenomenon occurs at point A ? State the condition needs to be satisfied by ϑ such that this phenomenon **fails to occur**.

7. (a)	(i)	Angle of incidence at A, $i_A = 90° - 30° = 60°$	1A 1	Well answered
	(ii)	$n_g \sin c = n_c \sin 90°$ $\Rightarrow \frac{n_g}{n_c} = \frac{1}{\sin c} \geq \frac{1}{\sin 60°} = 1.1547005 \approx 1.15$	1M 1A 2	1M for correct equation with angle of refraction in the cladding = 90° Accept 1.2 or $\frac{2}{\sqrt{3}}$
	(iii)	Total internal reflection. For light rays from O with $\theta > 30°$, they will fail to undergo total internal reflection.	1A 1A 2	Correct spelling Accept $\theta \geq 30°$

7(b)(i) Explain why the light pulse detected is **broader** (i.e. of a longer duration) and with **lower intensity**. Assume that the loss of energy of the light pulse due to absorption by glass is negligible.

(b)	(i)	Some light / energy (of the narrow light pulse) taking the shortest path (i.e. OD) arrives first while the rest of the energy taking longer paths arrives later. Therefore the pulse is broader and the height of the pulse is lower (smaller intensity).	1A 1A 2	1A for taking different paths 1A for different arrival time NOT accept: Some of the energy (going at angles larger than 30° from the axis) would be lost due to leakage, thus lower intensity.

7(b)(ii) An engineer suggests changing the refractive index n_c of the cladding in order to reduce the width of the light pulse received. should n_c be increased or decreased ? Or, will a change in n_c have no effect on the pulse width ? Explain your choice.

	(ii)	The refractive index of cladding should be increased, as $\frac{n_g}{n_c} = \frac{1}{\sin c}$, by making c / $\sin c$ larger, only those light rays close to the axis / within a smaller θ are totally internal reflected, (such that $\frac{n_g}{n_c}$ getting closer to 1).	1A 1A 2	0 A for the explanation if the choice for the change of n_c is INCORRECT. Note: More light rays will escape the optical fibre for a larger n_c.

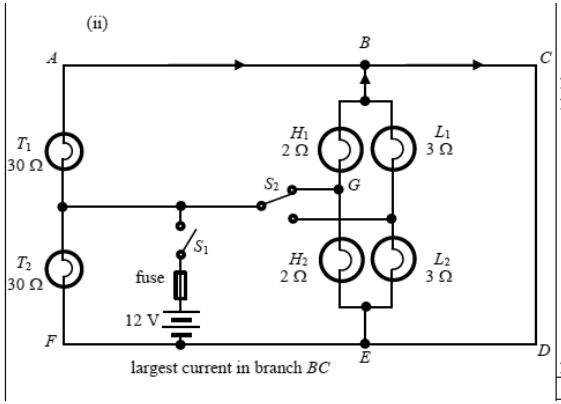
8(a) Explain why L_1 and L_2 are **not lit**.

(b)(i) What is the potential difference across the taillight T_2 ?

8.	(a)	Because L_1 and L_2 (connected in series) are shorted by $BCDE$	1A 1	Accept : p.d. across each low-beam headlight is 0.
	(b) (i)	p.d. across T_2 = 12 V	1A 1	Well answered

8(b)(ii) Indicate on Figure 8.1 the direction of current in each of the branches *AB*, *GB* and *BC*. Which branch carries the largest current ?

(ii)



largest current in branch *BC*

1A		Any two currents correctly marked.
1A		All currents correct.
1A		
	3	

8(c) Calculate the power delivered by the battery and show that the equivalent resistance of the circuit is slightly less than 1 Ω in this setting.

(c) Power supplied $P = 2 \times \left(\frac{12^2}{30} + \frac{12^2}{2}\right)$

$= 153.6$ W $= 154$ W (3 sig. fig.)

$\frac{V^2}{R_{eq}} = \frac{12^2}{R_{eq}} = 153.6$ (or $\frac{1}{R_{eq}} = \frac{1}{30} + \frac{1}{30} + \frac{1}{2} + \frac{1}{2}$)

$R_{eq} = 0.9375\ \Omega \approx 0.938\ \Omega \approx 1\ \Omega$ (3 sig. fig.)

1M		1M for same voltage across each bulb (T_1, T_2, H_1 and H_2) e.c.f. from (b)(i)
1A		
1M		1M for all bulbs (T_1, T_2, H_1 and H_2) in parallel
1A		
	4	

8(d) Based on your answer in (c), explain whether a fuse rating of 15 A is suitable for this circuit or not.

(d) max. current $I_{max} = \frac{V}{R_{eq}} = \frac{12}{0.9375} = 12.8$ A

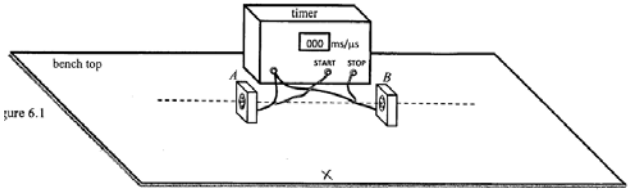
(or $I_{max} = \frac{P}{V} = \frac{153.6}{12} = 12.8$ A)

Since the rating is slightly higher than the max. current (when high-beam headlights and taillights are switched on), it is suitable.

1M		e.c.f. from (c)
1A		1A for 12.8 A and correct conclusion
	2	

Thanks

Candidates' response - 6(a)



gure 6.1

0A

Ruler to measure path difference. Hit the plate at different place, then sound and soft sound will be heared.

1A
0A

Candidates' response - 6(b)(i)

average = $\frac{801+838+539+821}{4}$ = 749.75 μs

∴ By $v = \frac{d}{t}$

$v = \frac{0.280}{749.75 \times 10^{-6}}$

= 373 ms^{-1}

1M
0A

b)i) $t = \frac{(801+838+821)}{3}$ = 820 μs

$f = \frac{1}{t}$ = 1219 Hz

$v = f\lambda$ = 1219 × 0.28 = 341 ms^{-1}

0M
0A

Candidates' response - 6(b)(ii)

(b ii) Repeat the experiment with different separation between A and B to obtain a more accurate result.

0A

ii) ~~Plot the~~ produce the sound with a shorter distance which a more accurate and clear ~~in~~ result. Also, connect the set-up with data-logger for a more accurate time used to reduce the error.

0A

Candidates' response - 7(a)(ii)

$n_g(\sin 30) = n_c(\sin 60)$

$\frac{n_g}{n_c} = 1.73$

0M
0A

$\frac{n_g}{n_c} = \frac{1}{\sin 60}$

$= 0.866$

1M
0A

$\sin 60 = \frac{n_c}{n_g}$

$\frac{n_g}{n_c} = \frac{2}{\sqrt{3}}$

$\frac{n_g}{n_c} = \frac{2}{\sqrt{3}}$

1M
1A

Candidates' response - 7(a)(iii)

Total internal reflection.
θ < critical angle

0A
0A

A點發生了全內反射，但θ大於30°，這現象則不會發生

0A
1A

internal reflection ~~occur~~ occurs at point A.
When the θ is smaller than (90 - critical angle), internal reflection would not occur.

0A
0A

Candidates' response - 7(b)(i)

the pulse is broaden because some light rays travells directly to the detector and some light rays are reflected several times in the optical fibre before reaching the detector, thus travelling longer dsifances, thus used longer time. The light pulse has lower intensity because energy is reduced due to diffraction of light since the light sensor is not directly in front of the fibre, thus some light ray are diffracted before detected by the detector

1A
1A

Ignored

As the speed of light is reduced after the light source at O is diffracted in all directions. So the light sensor can only sense part of the light which has lower intensity and reach at different time.

0A
1A

Candidates' response - 7(b)(ii)

n_c should be increased. By $n_1 \sin\theta = n_2 \sin\theta_2$, If n_1 and θ_1 remains constant, n_2 should be increased so as to get a smaller θ_2.

1A
0A

應減少 n_c，增加 n_c 代表了臨界角增加，當臨界角增加，可全內反射的角度則減少，同時減少光線因不同角度導致的時延差，令亮度減少

0A
0A

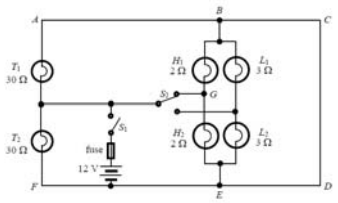
Candidates' response - 8(a)

current will go through G to B then to C, D, E then back to the battery, it will not pass through L_1 and L_2 since the path BCDE has almost no resistance

1A

Because there are resistance in L_1 and L_2 while no resistance in BC to CD to DE to battery.

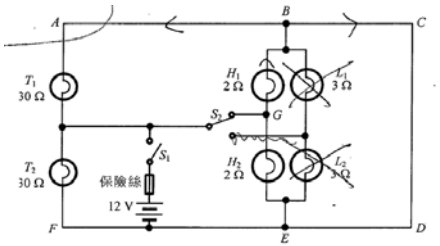
0A



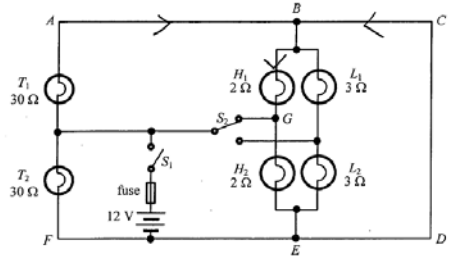
It is because they are in open circuit, no current flows through them.

0A

Candidates' response - 8(b)(ii)



1A
0A



0A
0A

Candidates' response - 8(c)

等效電阻 $= \left(\left(\frac{1}{2}+\frac{1}{2}\right)^{-1} + 30^{-1} + 30^{-1}\right)^{-1}$

$= 0.9375\,\Omega < 1\,\Omega$

Answer from incorrect method

功率 $= \frac{V^2}{R}$

$= \frac{12^2}{0.9375}$

$= 153.6\,W$

0M
0A
1M
1A

C

slightly less than 1 Ω in this setting.

$R = (\frac{1}{6}+\frac{1}{4})^{-1}$

$= 2.4\,\Omega$

$R = \left(\frac{1}{30}+\frac{1}{2.4+30}\right)^{-1}$

$= 16.4$

$P = \frac{V^2}{R}$

$P = \frac{12^2}{16.4}$

$= 9.35\,W$

Power of $T_2 = \frac{12^2}{30} = 4.8\,W$

0M
0A
1M
0A

Candidates' response - 8(d)

$V = IR$

$12 = I(0.938)$

$I = 12.8\,A$

since the rated value of 15A fuse is much larger than the rated current, so no.

1M
0A

Yes, by $V = IR$ $12 = I(0.999)$ $I = 12.0\,A$, so 15A is suitable because the circuit can run at 12 A or slightly above but prevents it from having a current too high that might result in a fire due to overheat because 15A is not a lot higher than 12A

0M
0A

REVIEW OF 2020 HKDSE PHYSICS EXAM

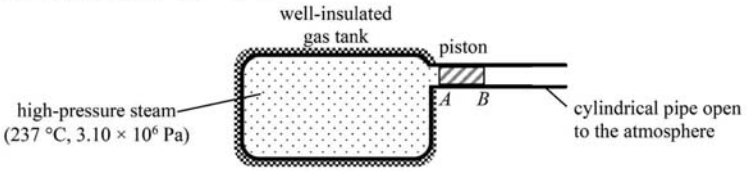
PAPER 1B

Q. 2, 9 &10

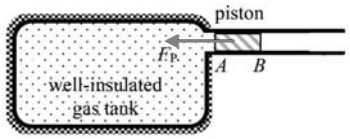
QUESTION 2(a)(i)

2. Figure 2.1 shows a large gas tank connected with a cylindrical pipe open to the atmosphere. The pipe is fitted with a smooth piston *AB*. This well-insulated gas tank is filled with high-pressure steam at a temperature of 237 °C under a pressure of 3.10×10^6 Pa while the movable piston is held stationary by a force F_p.
Given: atmospheric pressure = 1.0×10^5 Pa

Figure 2.1

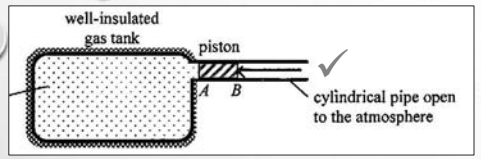


(a) (i) On Figure 2.1 indicate the force F_p. (1 mark)

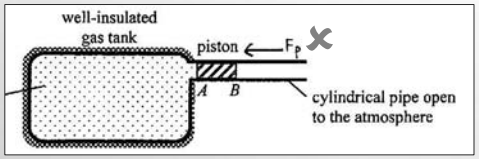
Marking Scheme	Candidates' Performance
 [F_p correctly marked] [1A]	Well answered. Some candidates did not indicate where the force acts.

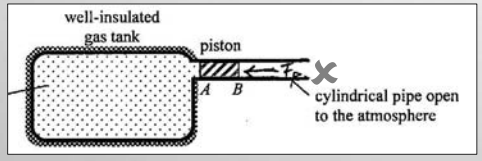
QUESTION 2(a)(i) Samples

(a) (i) On Figure 2.1 indicate the force F_p. (1 mark)



Accept force without label [1A]





Not showing where the force acts (not in contact with the piston) [0A]

QUESTION 2(a)(ii)

*(ii) By considering the force acting on the piston due to the difference in pressure, find the value of F_p. The piston has a cross-sectional area of 0.67 m^2. (2 marks)

Marking Scheme	Candidates' Performance
$F_p = (3.10 \times 10^6 - 1.0 \times 10^5) \times 0.67$ [1M] $= 2010000$ N $= 2.01 \times 10^6$ N [1A]	Quite a number of them mistook 'force = pressure /area'. Some calculated the force by the steam or the force due to atmospheric pressure instead of the force keeping the piston stationary.

QUESTION 2(a)(ii) Samples

*(ii) By considering the force acting on the piston due to the difference in pressure, find the value of F_p. The piston has a cross-sectional area of 0.67 m^2. (2 marks)

$$F = \frac{3.1 \times 10^6 - 1 \times 10^5}{0.67}$$
$$= 4.48 \times 10^6 \text{ N}$$

Force = Δp/area [0M]
Wrong answer [0A]

$$F_p = 3.10 \times 10^6 \times (0.67)$$
$$= 2077000 \text{ N}$$
$$= 2.077 \times 10^6 \text{ N}$$

***Fp* = force by the steam** [1M]
= (3.10×10⁶) × 0.67
Wrong answer [0A]

$$P = \frac{F}{A}$$
$$F_{net} = 0$$
$$1 \times 10^5 \times 0.67 = F_p$$
$$F_p = 67000 \text{ N}$$

***Fp* = force against atmospheric pressure** [0M]
Wrong answer [0A]

QUESTION 2(a)(iii)

*(iii) Estimate the volume of the gas tank which contains 570 kg steam. You may treat the steam as an ideal gas. Given: mass of one mole of steam = 0.018 kg. (3 marks)

Marking Scheme	Candidates' Performance
$pV = nRT \Rightarrow V = \frac{nRT}{p}$ $V = \frac{(570/0.018)(8.31)(237+273)}{3.10\times10^6}$ [1M+1M] $= 43.292419\ \text{m}^3 \approx 43.3\ \text{m}^3$ [1A]	A few took the temperature of steam to be 273°C or the Celsius temperature plus 237. Some wrongly took the number of mole *n* to be 1.

QUESTION 2(a)(iii) Samples

*(iii) Estimate the volume of the gas tank which contains 570 kg steam. You may treat the steam as an ideal gas. Given: mass of one mole of steam = 0.018 kg. (3 marks)

$(3.10 \times 10^6)V = n(8.31)(237)$

$(3.10\times10^6)V = \frac{570}{0.018}(8.31)(237)$ ✓ ✓

$V = 20.118$

$= 20.1\ \text{cm}^3$ ✗

Correct *n* [1M]
Correct equation (correct values of *P*, *n* and *R*, accept *T* = 237) [1M]
Wrong answer [0A]

By $pV = nRT$

$(3.10 \times 10^6) \times V = 1 \times 8.31 \times (273°\text{C}+273°\text{C})$ ✗ ✗

$V = 1463632258\ \text{m}^3$

$= 1.46 \times 10^9\ \text{m}^3$ ✗

Wrong *n* [0M]
Wrong equation (wrong *T*) [0M]
Wrong answer [0A]

$pV = nRT$

$(3.10\times10^6)V = \left(\frac{570}{0.018}\right)$ ✓ $\times 8.31 \times (237+237)$ ✗

$V = 46.348\ \text{m}^3$

$= 46.3\ \text{m}^3$ ✗

Correct *n* [1M]
Wrong equation (wrong *T*) [0M]
Wrong answer [0A]

QUESTION 2(a)(iii) Samples

*(iii) Estimate the volume of the gas tank which contains 570 kg steam. You may treat the steam as an ideal gas. Given: mass of one mole of steam = 0.018 kg. (3 marks)

Mole of steam $= \frac{570}{0.01}$ ✗ $= 57000$

$pV = nRT$

$V = \frac{57000\ R(237)}{3.10\times10^6}$ ✗

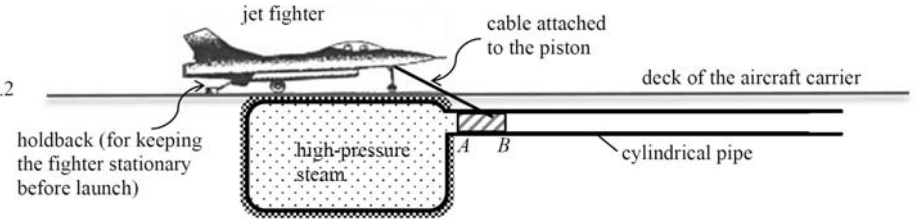
$= 36.2\ \text{m}^3$ ✗

Wrong *n* [0M]
Wrong equation (*R* not substituted & wrong answer) [0M]
Wrong answer [0A]

QUESTION 2(b)

(b) This set-up can be used as a 'steam catapult' to launch jet fighters from an aircraft carrier. A jet fighter in position to be launched is connected to the piston via an inextensible cable as shown in Figure 2.2. When the holdback behind the jet fighter is released, the high-pressure steam in the gas tank expands and pushes the piston which in turn helps to accelerate the jet fighter.

Figure 2.2



In a trial run of the catapult, a jet fighter (with its engine shut down) acquires a final speed of 54 m s^{-1} in 1.5 s after running a distance horizontally on the deck. The mass of the jet fighter is 2.6×10^4 kg.

QUESTION 2(b)(i)

(i) Find the work done by the net force on the jet fighter during launch. (2 marks)

Marking Scheme	Candidates' Performance
Work done = K.E. gained $= \frac{1}{2}(2.6 \times 10^4)\,54^2$ [1M] $= 3.7908 \times 10^7$ J ≈ 37.9 MJ [1A]	Most managed to find the work done by considering the gain of kinetic energy of the jet fighter. Many candidates, who employed work done equals force × distance, wrongly used the initial force and/or mistook the distance travelled as the product of the final velocity and time taken. Weaker ones only found the net force instead of the work done or considered the work done as mass × acceleration or force × velocity.

QUESTION 2(b)(i) Samples

(i) Find the work done by the net force on the jet fighter during launch. (2 marks)

Workdone $= F \times d = ma \times d$

$a = \frac{54-0}{1.5} = 36\ \text{m s}^{-2}$, $d = 54 \times 1.5$ ✗ $= 81$ m

$\therefore$ workdone $= 2.6 \times 10^4 \times 36 \times (54 \times 1.5)$

$= 75816000$ N ✗

Wrong equation ($d = v_{max} \times t$) [0M]
Wrong answer (value & unit) [0A]

$F = \frac{\Delta p}{A}$ Work $= F_{//} s$

$= \frac{3.1 \times 10^6 - 1 \times 10^5}{0.67}$ $= 4.48 \times 10^6 \times 40.5$

$= 4.48 \times 10^6$ N ✗ $= 1.81 \times 10^8$ J ✗

$s = \frac{1}{2}(u+v)t = 40.5$ m

Wrong equation (F = calculated F_{max}) [0M]
Wrong answer [0A]

$s = vt$ $W = F \cdot s$

$= (54)(1.5)$ $= 2010000 \times 81$ ✗

$= 81$ $= 162810000$ ✗

Wrong equation ($F = F_{max}$, $d = v_{max} \times t$) [0M]
Wrong answer (value & no unit) [0A]

QUESTION 2(b)(i) Samples

(i) Find the work done by the net force on the jet fighter during launch. (2 marks)

$v = u + at$ $F = ma$

$54 = 1.5a$ $= 2.6 \times 10^4 \times 36$

$a = 36\ \text{m s}^{-2}$ $= 9.36 \times 10^5$ J ✗

No equation for WD [0M]
WD not calculated [0A]

By $W = F \cdot v$

$W = (ma)v$ ✗

$W = (2.6 \times 10^4)\left(\frac{54-0}{1.5}\right)(54)$

$W = 5.05 \times 10^7$ J ✗

Wrong equation (WD = power) [0M]
Wrong answer [0A]

work done $= ma$ ✗

$(2.6 \times 10^4)(54)$

$= 1404000$

$= 14.04 \times 10^5$ N ✗

$W = \frac{mv - mu}{t}$ ✗

$= \frac{2.6 \times 10^4 (54-0)}{1.5}$

$= 9.36 \times 10^5$ N ✗

Wrong equation (WD = average force) [0M]
Wrong answer (value & unit) [0A]

QUESTION 2(b)(ii)

(ii) Calculate the average acceleration of the jet fighter during launch. (2 marks)

Marking Scheme	Candidates' Performance
Average acceleration a $= \frac{v-u}{t} = \frac{54-0}{1.5}$ [1M] $= 36\ \text{m s}^{-2}$ [1A]	Candidates did well in this part. Some struggled to obtain 'an average value' for the correctly calculated average acceleration !

QUESTION 2(b)(ii) Samples

(ii) Calculate the average acceleration of the jet fighter during launch. (2 marks)

$F = ma$

$2.01 \times 10^6 = 2.6 \times 10^4\ a$ ✗

$a = 77.3\ \text{m s}^{-2}$ ✗

Wrong equation (equation for initial acceleration) [0M]

Wrong answer [0A]

$v^2 = u^2 + 2as$

$0 = 54^2 + 2a(54 \times 1.5)$ ✗

$a = -18\ \text{m s}^{-2}$ ✗

Wrong equation (wrong u & v, $s = v_{max} \times t$) [0M]

Wrong answer [0A]

$a = \dfrac{v-u}{t} = 36\ \text{m s}^{-2}$

Average acceleration $= \dfrac{36}{1.5} = 24\ \text{m s}^{-3}$ ✗ ✗

Wrong equation (average acceleration = 'acceleration'/time) [0M]

Wrong answer (value & unit) [0A]

QUESTION 2(b)(iii)

*(iii) State whether the acceleration of the jet fighter is increasing, decreasing or uniform during launch. Explain your answer. (3 marks)

Marking Scheme	Candidates' Performance
Acceleration is decreasing (i.e. maximum at first). [1A] (According to kinetic theory,) once the steam expands, i.e. volume increases, its pressure decreases, [1A] thus the (pressure) force acting on the piston at A decreases, hence a smaller acceleration. [1A]	Most candidates knew that the acceleration was decreasing but not many were able to give a clear explanation. Some confused 'decreasing' with 'decreased' and stated that 'friction reduces the speed and hence acceleration is decreasing'.

QUESTION 2(b)(iii) Samples

*(iii) State whether the acceleration of the jet fighter is increasing, decreasing or uniform during launch. Explain your answer. (3 marks)

Decreasing. ✓ As the piston is pushed, the pressure of the steam decreases, ? and the force acting on the piston decreases, ✓ thus the acceleration decreases.

Correct answer [1A]

No explanation for decreasing pressure [0A]

Decreasing force [1A]

The acceleration is decreasing. ✓ It is because there is air resistance to decrease the acceleration. ?

Therefore, $F_{net} - f = ma$ is decreasing. ✓

Correct answer [1A]

No explanation for increasing air resistance [0A]

Decreasing force [1A]

The acceleration of the jet fighter is decreasing ✓ during the launch. Since friction between wheels and floor ~~rel~~ reduce ✗ the speed of the jet in which the force of jet is also reduced. ✗ $F = ma$. Hence, a also decrease.

Correct answer [1A]

No increasing resistance [0A]

Force reduced (not decreasing) [0A]

QUESTION 2(b)(iii) Samples

*(iii) State whether the acceleration of the jet fighter is increasing, decreasing or uniform during launch. Explain your answer. (3 marks)

decreasing. ✓ Because ~~it~~ ~~is~~ ~~d~~ the speed is decrease during launch. ✗

Correct answer [1A]

Wrong explanation (speed increases at a decreasing rate NOT decreases) [0A][0A]

Increasing. ✗ As there's external force acting on the inextensible cable to pull the jet fighter, ~~incre~~ increasing it's speed, thus accelerating. ✗

Wrong answer [0A]

Wrong explanation (accelerating ≠ acceleration increasing) [0A] [0A]

QUESTION 9(a)

9. Two small metal spheres are attached to the ends of an insulating rod of length 5.0 cm. They carry charges $+Q$ and $-Q$ respectively of equal magnitude as shown in Figure 9.1. The insulating rod is suspended horizontally between two parallel metal plates, A and B, which are connected to an E.H.T. (extra high tension) supply.

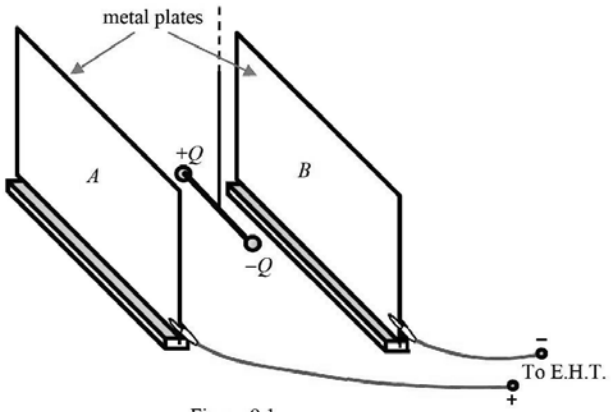


Figure 9.1

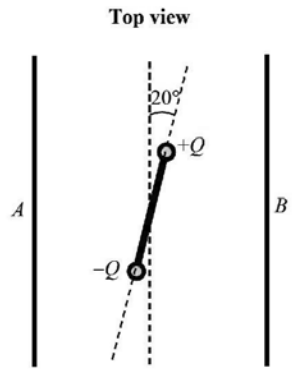
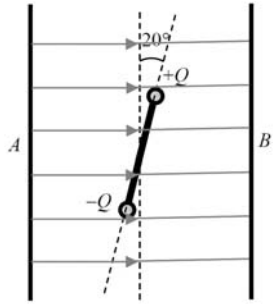


Figure 9.2

The rod is parallel to the metal plates when the E.H.T. is off. After the E.H.T. is switched on, an electric field is set up between the plates and the rod is twisted by an angle of 20° as shown in Figure 9.2.

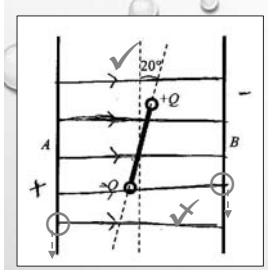
QUESTION 9(a)

(a) On Figure 9.2, sketch the electric field lines due to the potential difference across the plates. (2 marks)

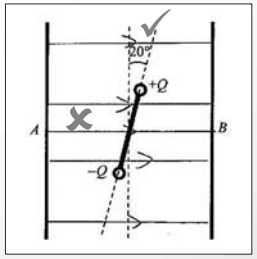
Marking Scheme	Candidates' Performance
 [Correct direction (from A to B) [1A] Perpendicular to plates, parallel and evenly spaced] [1A]	Although most candidates were able to show the correct direction of the electric field, many failed to draw evenly spaced, parallel field lines properly.

QUESTION 9(a) Samples

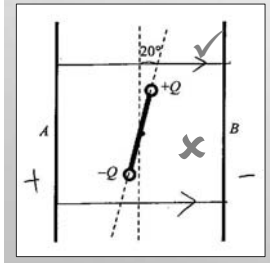
(a) On Figure 9.2, sketch the electric field lines due to the potential difference across the plates. (2 marks)



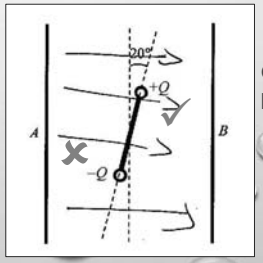
Correct direction [1A]
Perpendicular to plates, parallel and evenly spaced (Accept 1 or 2 slight mistakes) [1A]



Correct direction [1A]
Unevenly spaced [0A]



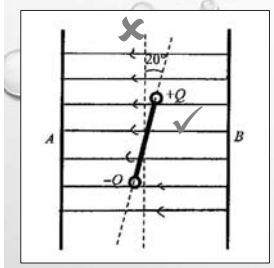
Correct direction [1A]
Evenly spaced not shown (only 2 lines) [0A]



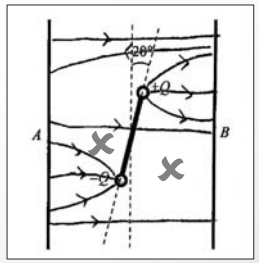
Correct direction [1A]
Not perpendicular to plates, not parallel and unevenly spaced [0A]

QUESTION 9(a) Samples

(a) On Figure 9.2, sketch the electric field lines due to the potential difference across the plates. (2 marks)



Wrong direction [0A]
Perpendicular to plates, parallel and evenly spaced [1A]



Wrong direction [0A]
Wrong pattern [0A]

QUESTION 9(b)(i)

(b) The potential difference across A and B is 5.0 kV and the separation between the metal plates is 10 cm. The force due to the electric field acting on each sphere is 2.0×10^{-5} N, find

(i) the moment acting on the rod as shown in Figure 9.2 due to the electric forces on the charged spheres. (2 marks)

Marking Scheme	Candidates' Performance
$F \times d = (2.0 \times 10^{-5})(0.05 \cos 20°)$ [1M] $= 9.396926 \times 10^{-7}$ N m $\approx 9.40 \times 10^{-7}$ N m [1A]	Not many were able to use the correct component of force or moment arm to find the moment acting on the rod. Many mistook the length of the rod as the moment arm. A few considered the moment to be the product of force and the separation of the plates. Some mistook J or N as the unit of moment.

QUESTION 9(b)(i) Samples

(b) The potential difference across A and B is 5.0 kV and the separation between the metal plates is 10 cm. The force due to the electric field acting on each sphere is 2.0×10^{-5} N, find

(i) the moment acting on the rod as shown in Figure 9.2 due to the electric forces on the charged spheres. (2 marks)

$\cos 20 = \dfrac{F_\perp}{2.0 \times 10^{-5}}$

$F_\perp = 1.879385242$

Moment $= F_\perp \times d \times 2 = 1.879 \times 0.025 \times 2 = 0.09395$ J ✗

Correct equation [1M]
Wrong answer (value & unit) [0A]

Moment $= Fd$

$= 2.0 \times 10^{-5} \times 0.05$ ✓

$= 1 \times 10^{-6}$ N s ✗

2×10^{-5} N $\times (5 \div 2 \div 100) \times \sin 20°$ ✓

$= 1.7101 \times 10^{-7}$ N/m

$1.7101 \times 10^{-7} \times 2 = 3.4202 \times 10^{-7}$ N/m ✗

Correct equation (accept *d* as moment arm or wrong component of *F*) [1M]
Wrong answer (value & unit) [0A]

QUESTION 9(b)(i) Samples

(b) The potential difference across A and B is 5.0 kV and the separation between the metal plates is 10 cm. The force due to the electric field acting on each sphere is 2.0×10^{-5} N, find

(i) the moment acting on the rod as shown in Figure 9.2 due to the electric forces on the charged spheres. (2 marks)

Moment $= F \times d$

$= (2 \times 10^{-5})\left(\dfrac{5}{100}\right)\left(\dfrac{1}{2}\right)$ ✓

$= 5 \times 10^{-7}$ N m ✗

Correct equation (accept no component of *F* & moment due to force on one charge) [1M]
Wrong answer [0A]

$F \times d = (2 \times 10^{-5})\left(\dfrac{10}{100}\right)$ ✗

$= 2 \times 10^{-6}$ N ✗

Wrong equation (moment arm = separation between plates) [0M]
Wrong answer (value & unit) [0A]

QUESTION 9(b)(ii)

*(ii) the strength of the electric field E due to the potential difference across the metal plates. (2 marks)

Marking Scheme	Candidates' Performance
$E = \dfrac{V}{d}$ $= \dfrac{5.0 \times 10^3}{0.1}$ [1M] $= 50\,000$ V m^{-1} or N C^{-1} [1A] $= 50$ kV m^{-1} or kN C^{-1}	Most candidates answered correctly. Wrong units for the electric field were found occasionally.

QUESTION 9(b)(ii) Samples

*(ii)the strength of the electric field E due to the potential difference across the metal plates. (2 marks)

$E = \frac{5000}{0.1}$ ✓

$= 50000$ J ✗

$E = \frac{5\times1000}{10\div100}$ ✓

$= 50000$ V ✗

$E = \frac{V}{d}$

$= \frac{5\times1000}{0.1}$ ✓

$= 50000$ T ✗

$\frac{5000}{0.1}$ ✓ $= 50000\ \text{N m}^{-2}$ ✗

Correct equation [1M]

Wrong answer (wrong or no unit) [0A]

$E = \frac{V}{d}$

$= \frac{5.0\times1000}{10\div100}$ ✓

$= 50\,000$ N ✗

$E = \frac{5.0\times1000}{0.1}$ ✓

$= 50000\ \ell\mathcal{B}$ ✗

$E = \frac{V}{d} = \frac{5}{10}$ ✓ $= 0.5$ ✗

QUESTION 9(b)(ii) Samples

*(ii)the strength of the electric field E due to the potential difference across the metal plates. (2 marks)

$E = \frac{5\times1000}{\frac{10}{1000}}$ ✓ $= 500\,000\ \text{N C}^{-1}$ ✗

Correct equation (accept wrong order of magnitude of d) [1M]

Wrong answer [0A]

$E = \frac{V}{d} = \frac{1\times10^{-6}}{0.1}$ ✗ $= 1\times10^{-5}\ \text{V s}^{-1}$ ✗

Wrong equation [0M]

Wrong answer (value & unit) [0A]

$F = \frac{Q^2}{4\pi\varepsilon_0 r^2}$

$E = \frac{Q}{4\pi\varepsilon_0 r^2} = \frac{\sqrt{4\pi\varepsilon_0 r^2 F}}{4\pi\varepsilon_0 r^2}$ ✗

$= \frac{4\pi\varepsilon_0(0.05)^2(2.0\times10^{-5})}{4\pi\varepsilon_0(0.05)^2} = 2.0\times10^{-5}$ ✗

Wrong equation [0M]

Wrong answer (value & unit) [0A]

$\frac{F}{Q}$

QUESTION 9(b)(iii)

(iii) the magnitude of the charge Q on the spheres. (2 marks)

Marking Scheme	Candidates' Performance
$E = \frac{F}{Q}$ $Q = \frac{F}{E} = \frac{2.0\times10^{-5}}{5.0\times10^{4}}$ [1M] $= 4.0\times10^{-10}$ C [1A]	Many candidates wrongly employed equations of force or electric field due to a point charge to tackle (b)(iii)

QUESTION 9(b)(iii) Samples

(iii) the magnitude of the charge Q on the spheres. (2 marks)

Force $= \frac{Q_1 Q_2}{4\pi\varepsilon_0 r^2}$

$= \frac{Q}{4\pi\varepsilon_0 r^2}(Q_2)$

$= E(Q_2)$

$\therefore 1.71\times10^{-7} = 50000Q$ ✗

$Q = 3.42\times10^{-12}$ C ✗

Wrong equation (wrong force) [0M]

Wrong answer [0A]

$F = \frac{Q_1 Q_2}{4\pi\varepsilon_0 r^2}$

$2.0\times10^{-5} = \frac{Q_1}{4\pi(8.85\times10^{-12})(5)^2}$ ✗

$Q = 5.56\times10^{-14}$ J ✗

Wrong equation [0M]

Wrong answer (value & unit) [0A]

QUESTION 9(b)(iii) Samples

(iii) the magnitude of the charge Q on the spheres. (2 marks)

$$E = \frac{Q}{4\pi\varepsilon_o r^2}$$

$$50000 = \frac{Q}{4\pi(5.0\times1000)(0.05)^2}$$ ✗

$$Q = 785 \times 10^5$$ ✗

Wrong equation [0M]
Wrong answer (value & unit) [0A]

QUESTION 10(a)

10. Given: mass of proton = 1.0073 u
mass of α particle = 4.0015 u
mass of $^{14}_{7}$N nucleus = 13.9993 u
mass of $^{17}_{8}$O nucleus = 16.9947 u

When a stationary $^{14}_{7}$N nucleus is bombarded by an α particle, the following nuclear reaction can be triggered with products $^{17}_{8}$O and X fly off:

$$\alpha + {}^{14}_{7}\text{N} \longrightarrow {}^{17}_{8}\text{O} + X$$

(a) What is X? (1 mark)

Marking Scheme	Candidates' Performance
proton / $^{1}_{1}$H / p / hydrogen nucleus [1A]	Well answered. Some candidates were unable to identify the product X despite they had found the correct proton and mass numbers.

QUESTION 10(a)

(a) What is X? (1 mark)

$^{-1}_{-1}X$ = a proton ✓

Accept 'proton' with wrong symbol [1A]

X is hydrogen atom. ✓

Accept 'hydrogen atom' [1A]

An isotope of H ✗ H_2 ✗

'Isotope of H' or 'H_2' not accepted [0A]

$^{1}_{1}X$ ✗ $^{1}_{1}n$ ✗ $^{1}_{1}H_e$ ✗

Correct atomic no. & mass no. without correct name or symbol not accepted [0A]

β ✗ neutron ✗ Gamma particle ✗

Wrong answer [0A]

QUESTION 10(b)

*(b)Based on energy consideration, estimate the minimum kinetic energy, in MeV, of the α particle required for such a nuclear reaction to occur. (2 marks)

Marking Scheme	Candidates' Performance
Change in mass $\Delta m = (16.9947 + 1.0073) - (13.9993 + 4.0015)$ [1M] $= 0.0012$ u Energy $= 0.0012 \times 931$ $= 1.1172$ (MeV) ≈ 1.12 (MeV) [1A]	Most managed to find the mass defect correctly. Some failed to convert the mass defect to energy in MeV. Weaker ones mistook the energy equivalent of the mass of α particle as the minimum kinetic energy or omitted the α particle or the proton in finding the minimum kinetic energy.

QUESTION 10(b) Samples

*(b)Based on energy consideration, estimate the minimum kinetic energy, in MeV, of the α particle required for such a nuclear reaction to occur. (2 marks)

minimum kinetic energy
$= \Delta mc^2$
$= (1.0073 + 16.9947 - 4.0015 - 13.9993) \times 1.661\times10^{-27} \times (3\times10^8)^2$ ✓
$= 1.79 \times 10^{-13}$ ✗

Correct Δm [1M]
Answer not converted to MeV [0A]

$\Delta E = \Delta mc^2$
$= (16.9947 + 1.0073 - 13.9993 - 4.0015) \times (3\times10^8)^2 \times 931$ ✓
$= 1.00548 \times 10^{17}$ MeV ✗

Correct Δm [1M]
Wrong answer (wrong method) [0A]

min. kinetic energy of α $= 4.0015 \times 931$ ✗
$= 3725.3965$ MeV ✗

Wrong Δm (mass of α particle only) [0M]
Wrong answer [0A]

QUESTION 10(b) Samples

*(b)Based on energy consideration, estimate the minimum kinetic energy, in MeV, of the α particle required for such a nuclear reaction to occur. (2 marks)

energy $= (16.9947 + 1.0073 - 13.9993) \times 931$ ✗
$= 3730$ MeV ✗

Wrong Δm (mass of α omitted) [0M]
Wrong answer [0A]

The required KE
$= (4.0015 + 13.9993 - 16.9947) \times 931$ ✗
$= 937$ MeV (3sf) ✗

Wrong Δm (mass of proton omitted) [0M]
Wrong answer [0A]

QUESTION 10(c)

(c) However, when conservation of momentum is also taken into account, the α particle must possess a kinetic energy greater than that found in (b) to bring about such a reaction. Explain. (2 marks)

Marking Scheme	Candidates' Performance
By the conservation of momentum, as before the reaction occurs the α particle has momentum, the total momentum of the products (= momentum of the α particle) must also be non-zero, [1A] i.e. the total KE of the products must greater than 0, thus the α particle should have a larger KE. [1A]	Candidates' performance was poor. Only a few were able to give a correct explanation based on the conservation of momentum. Popular explanations included • 'extra energy is needed because of inelastic collision or binding energy', • 'to compensate for the energy lost to surroundings' or • 'to overcome repulsive forces'.

QUESTION 10(c) Samples

(c) However, when conservation of momentum is also taken into account, the α particle must possess a kinetic energy greater than that found in (b) to bring about such a reaction. Explain. (2 marks)

Some momentum is converted in to the momentum of the $^{17}_{8}O$. ✓ of α particle

Product(s) has/have momentum [1A]
KE of product(s) not mentioned [0A]

As momentum of the system should be conserved before and after the reaction. ✗
So kinetic energy is required to compensate the energy loss when α particle collides with nucleus. ✗

Law of conservation of momentum only [0A]
KE of product(s) not mentioned [0A]

It is an inelastic collision, ✗
kinetic energy are not conserved in this reaction. ✗

Inelastic collision [0A]
KE of product(s) not mentioned [0A]

energy is loss to ionize the air molecules ✗ so a greater KE is needed. ✗

Energy to ionize air molecules [0A]
KE of product(s) not mentioned [0A]

QUESTION 10(c) Samples

(c) However, when conservation of momentum is also taken into account, the α particle must possess a kinetic energy greater than that found in (b) to bring about such a reaction. Explain. (2 marks)

To break the bonds holding the molecules. ✗

Energy to break the bonds [0A]
KE of product(s) not mentioned [0A]

~~In~~ Greater kinetic energy is required to overcome the electrostatic repulsive force between α particle and $^{14}_{7}N$. ✗

Energy to overcome repulsive force [0A]

Since greater energy is required to overcome the nucleic repulsion of $^{14}_{7}N$ atom. ✗ ∴ Greater energy of α particle is needed. ✗

KE of product(s) not mentioned [0A]

THANK YOU!

Paper 2

Section A: Astronomy and Space Science

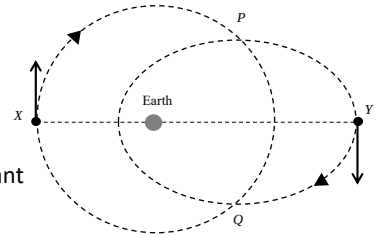
Q.1 Multiple-choice questions

	A	B	C	D	
1.1	21.5	4.9	11.8	**60.3***	
1.2	26.6	16.9	30.7	**23.7***	✓
1.3	13.8	13.9	**62.9***	7.4	
1.4	14.2	**44.1***	15.7	24.1	✓
1.5	13.2	16.5	**54.5***	12.9	
1.6	9.0	**56.5***	5.7	27.2	
1.7	23.7	15.9	**45.2***	13.0	✓
1.8	**51.7***	9.6	25.0	11.9	

*** : key** ; Red colour : most favourable distractor

MCQ 1.2

Two satellites *X* and *Y* are revolving in clockwise direction about the Earth as shown. The diameter of the circular orbit of *X* equals the length of the major axis of the elliptical orbit of *Y*. The two orbits intersect at *P* and *Q*.



At the instant shown, the two satellites and the Earth are on a straight line. Which deductions are correct ?

(1) X and Y have the same acceleration when they pass *P*.
(2) The speed of X is greater than that of Y at the instant shown.
(3) The satellites will not meet each other at *P* or at *Q*.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only favourable distractor 30.9%
*D. (1), (2) and (3) 23.7%

- At *P*, two satellites are at equal distance from the Earth.
- According to Law of Gravitation, the acceleration of *X* and *Y* is equal at *P* (applying also Newton's 2nd law)
- ∴ (1) is correct

- As the diameter of the circular orbit equals the major axis of the elliptical orbit, the circumference is larger for the circular orbit.
- Since the period is the same, average speed (circular) > average speed (elliptical) which is also greater than its lowest speed v_Y along the orbit (by Kepler's 2nd law)
- ∴ (2) is correct

- According to Kepler's 3rd law, the period of *Y* is the same as that of *X*.
- Two satellites never meet at *P* or *Q*
- ∴ (3) is correct

MCQ 1.4

The luminosity of star *P* is double that of star *Q*. The brightness of *P* is eight times that of *Q*. What can be deduced about the respective distance of stars *P* and *Q* from the Earth ?

A. *P*'s distance from the Earth is 2 times that of *Q*.
*B. *Q*'s distance from the Earth is 2 times that of *P*. 44.1%
C. *P*'s distance from the Earth is 4 times that of *Q*.
D. *Q*'s distance from the Earth is 4 times that of *P*. favourable distractor 24.1%

L= total power

Brightness= $\frac{Total\ power}{4\pi d^2}$

$$8 = \frac{\frac{P_P}{4\pi d_P^2}}{\frac{P_Q}{4\pi d_Q^2}} = 2\frac{d_Q^2}{d_P^2} \qquad \therefore \frac{d_Q}{d_P} = 2$$

MCQ 1.7

A star, which is 4.2 light years from the Sun, is observed from the Earth 6 months apart. Estimate the maximum angular difference in the observed positions of this star.

A. 0.8 arc seconds favourable distractor 23.7%
B. 1.3 arc seconds
*C. 1.6 arc seconds 45.2%
D. 2.6 arc seconds

1 pc = 3.26 ly

$\therefore \frac{1}{p} = \frac{4.2}{3.26}$ pc = 1.29 pc

$p = \frac{1}{1.29} = 0.8''$

i.e. 1.6 arc seconds after 6 months

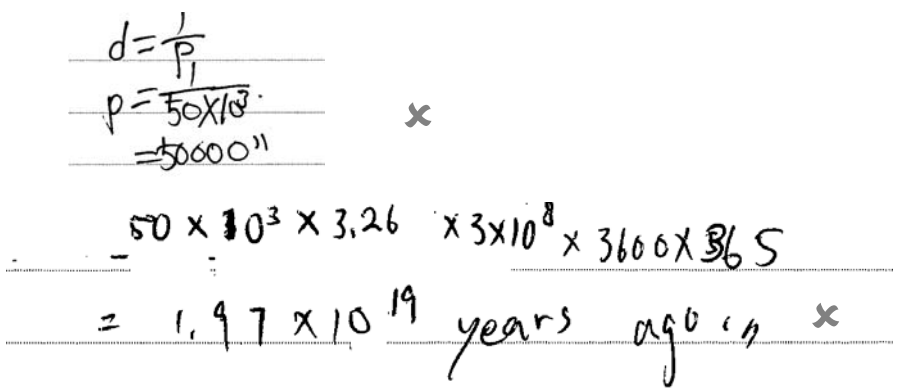
Q.1 Structured question

A certain star *X* at a distance of about 50 kpc from the Earth exploded a very long time ago and became Supernova 1987A (SN 1987A). The light from this supernova first reached the Earth in 1987.

(a) Estimate how long ago the above explosion took place. (Give your answer in years to 3 sig. fig.) (1 mark)

- **Distance 50 kpc = 50000 × 3.26 ly = 163000 ly**
- **Thus the explosion of the star took place 163000 years ago** **1M**
- **Note: 2020 – 1987 = 33 years can be ignored.**

Most candidates knew how to find when the explosion occurred although some of them made mistakes in units conversion.



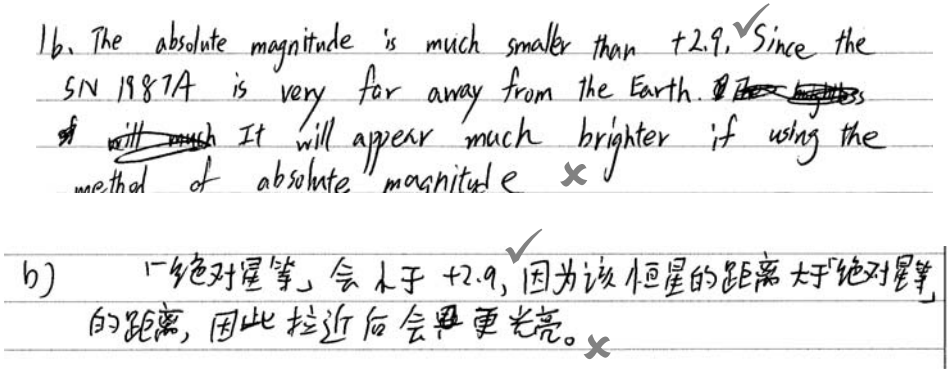
(b) At maximum brightness, SN 1987A has an apparent magnitude of +2.9. Is the *absolute magnitude* of SN 1987A at maximum brightness smaller than, larger than or equal to +2.9 ? Explain your answer. (2 marks)

SN 1987A at 50 kpc, being much farther away than 10 pc, would be much **brighter** (than that corresponding to +2.9) if it were placed at 10 pc. 1A

No mark awarded without 'placed at 10 pc'

Hence (the numerical value of) its absolute magnitude is much **smaller** than +2.9 / the apparent magnitude. 1A

Some candidates failed to point out that the absolute magnitude corresponds to observing the star as if it were placed at 10 pc.



Before the explosion of star *X*, its luminosity was about 40000 times that of the Sun and its surface temperature was 3.1 times that of the Sun.

(c)(i) Use Stefan's law to show that the radius of the star *X* is about 20 times the Sun's radius. (2 marks)

Correct expression derived from Stefan's law

$L_S = \sigma(4\pi R_S^2)T_S^4$ and $L_X = \sigma(4\pi R_X^2)T_X^4$

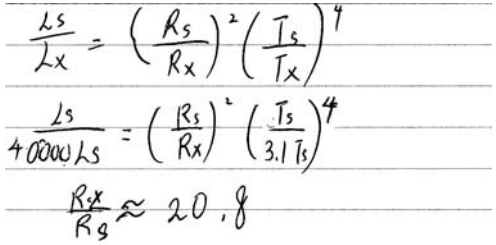
$\therefore \quad \frac{L_X}{L_S} = \left[\frac{R_X}{R_S}\right]^2\left[\frac{T_X}{T_S}\right]^4$ 1M

$40000 = \left[\frac{R_X}{R_S}\right]^2[3.1]^4$ Correct sub. into the correct expression

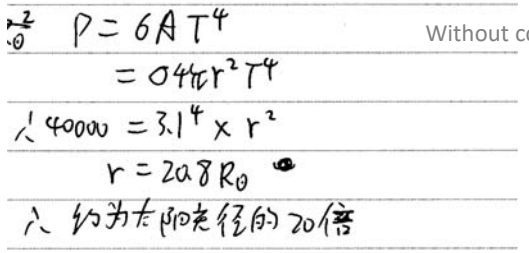
1M

$\frac{R_X}{R_S} = 20.81165 \approx 20.8$

Well answered. A few candidates forgot to start with Stefan's law.

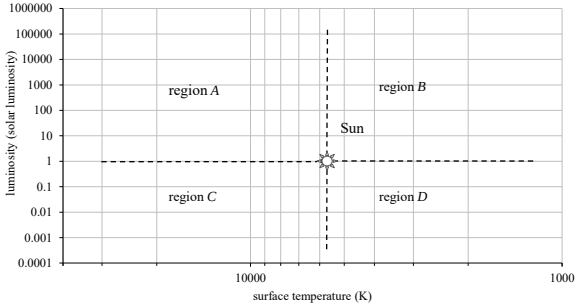


Did not start with Stefan's law



Without correct ratio

(c)(ii) In which region, *A*, *B*, *C* or *D*, on the Hertzsprung-Russell diagram was star *X* located ? Explain whether or not this star can be classified as a 'red giant'. (2 marks)

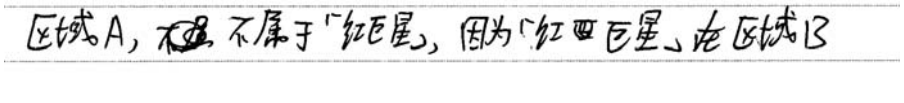


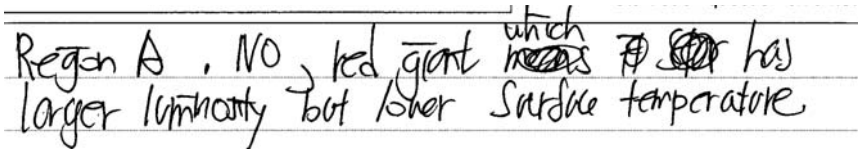
Region *A*. 1A

Not a 'red giant' as the temperature of star *X* is (much) higher than that of the Sun. / 1A

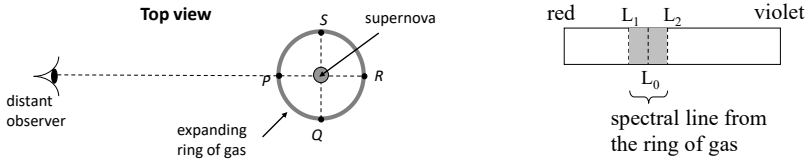
Red giants are in region *B*

Well answered. Most were able to identify features of star *X* that ruled out the possibility of classifying it as a 'red giant'.





(d) A special feature of SN 1987A is that a circular ring of gas surrounds the supernova. The gas was ejected by the star *X* some time before it exploded. As shown in Figure 1.1, each point on this ring is expanding outwards at a constant speed from the supernova.



Suppose a distant observer on the plane containing the ring views a certain spectral line from the ring of gas and finds that it covers wavelengths between the limits L_1 and L_2 as shown in Figure 1.1. L_0 is the wavelength of that spectral line when observed in the laboratory. State the respective wavelengths that originate from point *Q* and point *R* on the ring. Explain your answer. (3 marks)

L_0 should be Q as ✓the movement of Q due to expansion of gas ring is neither closer nor farther away from the observer i.e. no blue or red shift is observed ✗

L_0 是源自于Q点的波长，因为Q的扩张方向与观察者观察方向垂直，因此没有远离或靠近观察者，不属于蓝移及红移现象。 ✓

Q: L_0 or *R*: L_1 1A

According to Doppler effect, gas at *R* receding from the observer gives rise to red shift (vice versa for *P*) 1A
Accept: Moving away from the observer

While there is no velocity component for gas at *Q* (and *S*) towards / away from the observer, no Doppler / blue / red shift 1A
Accept: No velocity along the direction toward the observer.
The velocity of *Q* is perpendicular to the line joining *Q* and the observer
NOT accept: no relative velocity between *Q* and observer

Some candidates had a misconception that there was no Doppler effect as the distance of the star from the observer did not change.

Paper 2

Section C : Energy and Use of Energy

Q.3 Multiple-choice questions

	A	B	C	D
3.1	12.2	**65.3***	16.1	6.3
3.2	**83.0***	6.8	7.3	2.8
3.3	7.2	11.6	8.2	**72.9***
3.4	13.1	8.5	**54.6***	23.7
3.5	**65.0***	6.1	11.1	17.9
3.6	5.6	**24.1***	56.5	13.5
3.7	8.2	30.9	13.2	**47.7***
3.8	**85.3***	11.0	0.7	3.0

*** : key** ; Red colour : most favourable distractor

MCQ 3.6

3.6 A room is kept cool by an air-conditioner of cooling capacity P. The temperatures inside and outside the room are 27 °C and 31 °C respectively. The rate of heat flowing into the room by radiation through windows and that by conduction are in the ratio 1:4. If the cooling capacity is raised to $2P$ while the temperature outside the room is still 31 °C, estimate the temperature inside the room. Assume that the rate of heat flowing into the room by radiation is unchanged.

A.	21 °C			
* B.	22 °C		24.1%	
C.	23 °C	favourable distractor	56.5%	
D.	25 °C			

A ○ B ○ C ○ D ○

$$\frac{Q_C}{t} = UA\Delta T \qquad P = \frac{Q_C}{t} + \frac{Q_R}{t} = \frac{5}{4} \times \frac{Q_C}{t}$$

$$\frac{Q_C'}{t} = UA\Delta T' \qquad 2P = \frac{Q_C'}{t} + \frac{Q_R}{t}$$

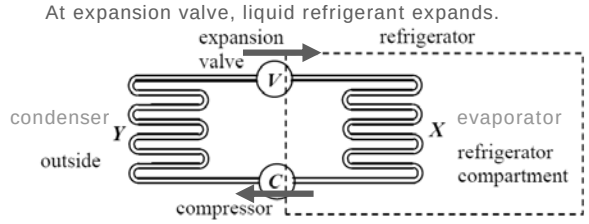
$$P = \frac{Q_C'}{t} - \frac{Q_C}{t}$$

$$\frac{5}{4} \times \frac{Q_C}{t} = \frac{Q_C'}{t} - \frac{Q_C}{t}$$

$$\frac{5}{4} \times UA\Delta T = UA\Delta T' - UA\Delta T \qquad \Delta T' = \frac{9}{4}\Delta T = 9\ ^{o}\text{C}$$

MCQ 3.7

3.7 A simplified schematic diagram of a refrigerator is as shown.



What is the direction of flow of the refrigerant through the expansion valve V ? Which component, X or Y, contains refrigerant at a higher temperature ?

	direction of flow of the refrigerant through the expansion valve	component that contains refrigerant at a higher temperature		
A.	$X \rightarrow V \rightarrow Y$	X		
B.	$X \rightarrow V \rightarrow Y$	Y	favourable distractor	30.9%
C.	$Y \rightarrow V \rightarrow X$	X		
* D.	$Y \rightarrow V \rightarrow X$	Y		47.7%

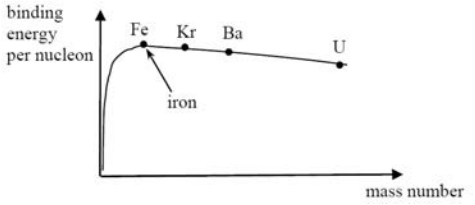
Q.3 Structured question

Pressurized water reactors constitute the majority of the world's nuclear power plants. In the reactor, energy is produced by the fission of uranium-235 nuclei ($^{235}_{92}\text{U}$). A typical fission reaction is as follows:

$$^{235}_{92}\text{U} + {}^{1}_{0}\text{n} \longrightarrow {}^{144}_{56}\text{Ba} + {}^{90}_{36}\text{Kr} + 2\,{}^{1}_{0}\text{n}$$

(a) Referring to the binding energy curve in Figure 3.1, explain why uranium-235 nuclei tend to undergo fission. (2 marks)

Figure 3.1



(a) The fission products / nuclides are with higher binding energy per nucleon than uranium-235. 1A
Therefore, energy is released in fission and the resulting nuclides are more stable. 1A
2

1A for comparing the binding energy per nucleon before and after fission of $^{235}_{92}\text{U}$
1A for more stable after fission

3a) Because the uranium 235 has lower binding energy than the daughters so uranium 235 needs to do fission. 0M

(a) 因为铀捕捉到一个中子，从而产生裂变，原子核最终会不断裂变到最右的稳定状态。 1M

(a) Because U-235 nuclei tend to become nuclei with higher binding energy per nucleon, the nucleus with highest binding energy per nucleon, as shown, is iron nucleus. Iron nucleus is smaller than U-235 nucleus. So U-235 nuclei tend to undergo fission to form smaller daughter nuclei and finally form iron nuclei 1M

In (a), not many were able to mention that an atom or a nucleus is more stable if it possesses a higher binding energy per nucleon.

b)(i) The energy between molecules in nucleus that holds the nucleus together. 0M

b)(i) 当铀-235分裂时会有质量减少而减少的质量是会转化作能量，当中更使分裂后的铀235再次启动自动启能。 0M

In (b), many candidates did not fully understand what 'binding energy' means and failed to state its physical meaning of 'energy required to separate the nucleons completely'. Weaker ones held that it was the amount of energy needed to 'bind' the nucleus from its constituent nucleons.

(ii) 能量：$92 \times 1783 - 56 \times 8.27 - 36 \times 8.59$
$= 1.63 \times 10^5$ MeV 0M

(ii) Energy released = $1783 - 8.27 - 8.59 = 1766.14$ MeV 0M

For the calculation in (b)(ii), some incorrectly multiplied the binding energy per nucleon by the difference of mass number and atomic number.

Q.3 Structured question

(b) The binding energy of a uranium-235 nucleus is 1783 MeV.

(i) What does the above statement mean ? (1 mark)

(ii) Find the energy released, in MeV, in the fission of a uranium-235 nucleus.
Given: Binding energy per nucleon of $^{144}_{56}Ba$ nucleus = 8.27 MeV per nucleon
Binding energy per nucleon of $^{90}_{36}Kr$ nucleus = 8.59 MeV per nucleon (2 marks)

(b) (i) It represents the energy required to separate all nucleons (protons and neutrons) of uranium-235 to infinity / far apart / separate completely. 1A

NOT accept: separate the nucleus into independent / individual nucleons 1

Accept:
Energy released by combining protons and neutrons (nucleons) into a single nucleus.

(ii) Binding energy (B.E.) of $^{235}_{92}U$ nucleus = 1783 MeV
B.E. of $^{144}_{56}Ba$ nucleus = $8.27 \times 144 = 1190.88$ MeV
B.E. of $^{90}_{36}Kr$ nucleus = $8.59 \times 90 = 773.1$ MeV 1M
Hence, energy released in fission
$= (1190.88 + 773.1) - 1783$
$= 180.98$ (MeV) ≈ 181 (MeV) 1A
2

1M for calculating the total binding energy of $^{144}_{56}Ba$ & $^{90}_{36}Kr$ from the binding energy per nucleon

Accept:
180 – 181 MeV
$(2.88 – 2.90) \times 10^{-17}$ J

Q.3 Structured question

(c) (i) In the reactor of a nuclear power plant, a total energy of 1.30×10^{30} MeV would be released if all uranium-235 nuclei in the fuel rods have undergone fission. Given that the mean power output of the power plant is 500 MW and the efficiency in converting nuclear energy to electrical energy is 40%. Estimate the time, in years, for which the fuel rods can be used. (Take 1 year = 3.15×10^7 s) (2 marks)

(ii) State a reason why the fuel rods are usually replaced before the time estimated in (c)(i) has elapsed. (1 mark)

(c) (i) $\frac{\text{Total energy released} \times \text{efficiency}}{\text{Power output}}$

$= \frac{(1.30 \times 10^{30} \times 10^6)(1.6 \times 10^{-19})(0.4)}{500 \times 10^6}$ 1M

$= 1.664 \times 10^8$ s ≈ 5.28254 years ≈ 5.28 years 1A

$\frac{(1.30 \times 10^{30})}{931}(1.661 \times 10^{-27})(3 \times 10^8)^2 (0.4)$ / 500×10^6 = 5.30 years

2

1M for $\frac{(1.30 \times 10^{30} \times 10^6)(1.6 \times 10^{-19})}{500 \times 10^6}$

Accept: 5.28 – 5.30 years

Note:
$\frac{(1.30 \times 10^{30} \times 10^6)(1.6 \times 10^{-19})}{500 \times 10^6} = 13.2$ years
$\frac{(1.30 \times 10^{30} \times 10^6)(1.6 \times 10^{-19})}{500 \times 10^6 (0.4)} = 33$ years

(ii) The concentration of uranium-235 nuclei will decrease with time and chain reaction cannot be maintained when the concentration is too low. 1A

1

Accept:
concentration / mass / amount
NOT accept:
reaction slows down

(i) $500 \times 10^6 \times 40\% = 2 \times 10^8$ W

1.3×10^{30} MeV

$= 1.3 \times 10^{30} \times 10^6 \times 1.6 \times 10^{-19}$

$= 2.08 \times 10^{17}$ W ✓

$\frac{2.08 \times 10^{17}}{2 \times 10^8} = 1040000000$ s

$= \frac{1040000000}{3.15 \times 10^7}$

$= 33$ 年 ×

∴ 燃料棒可用33年

1M

(i) $E = pt$

$1.30 \times 10^{30} \times 40\% = 500 \times 10^6 t$

$t = 1.04 \times 10^{21}$ s

∴ 可用 $= \frac{1.04 \times 10^{21}}{3.15 \times 10^7}$ ×

$= 3.30 \times 10^{13}$ 年

0M

Less than half of the candidates obtained the correct answer in (c)(i). Many made mistakes in units conversion or in manipulating the efficiency of energy conversion.

(ii) 核电厂的设备会逐渐老化。 ×

0M

(ii) 时间多到达前一段时间反应速率太慢，产生能量太低。 ×

0M

(ii) Because only high concentration of uranium-235 can undergo chain reaction of nucleus ✓ fission. The concentration of uranium drops to low level before 5.26 years.

1M

In (c)(ii), few were able to mention that chain reaction could not be sustained when the concentration of U-235 in the fuel rods was too low.

di) It slow down the speed of neutron ✓ during fission process.

dii) It control the rate of nuclear fission ×

1M

di) To help maintain the temperature of the generator. ×

ii) To control the rate of fission. ×

0M

(d) (i) 减速剂用来减低中子的速率，令反应堆反应速率上升。 ✓

(ii) 控制反应堆的温度 ×

1M

In (d), most candidates knew the function of moderator in a fission reactor though a few wrongly stated that 'electrons' or 'atoms' were to be slowed down.

For those who pointed out that control rods were to absorb neutrons, some did not further explain that they were for controlling the rate of reaction.

Q.3 Structured question

(d) Explain the role of the following in a fission reactor:

(i) moderator

(ii) control rods

(2 marks)

(d)	(i)	moderator: to slow down the fast neutrons produced in fission.	1A 1	
	(ii)	control rods: to control the rate of nuclear fission / reaction by absorbing the neutrons or for shutting down the reactor in case of emergency.	1A 1	1A: absorbing neutrons + controlling / slowing down the chain reaction Or absorbing neutrons + shutting down the reactor

Paper 2

Section B: Atomic World

HKDSE 2020

Multiple Choice

Qn.	1	2	3	4	5	6	7	8
A	38.9%	4.0%	29.4%	9.1%	40.2%	42.4%	11.2%	8.1%
B	16.7%	6.0%	26.5%	42.1%	19.8%	28.6%	61.3%	43.6%
C	28.4%	74.5%	9.5%	25.0%	21.3%	15.8%	12.6%	15.5%
D	15.2%	14.6%	33.6%	22.9%	17.9%	12.1%	14.7%	32.0%

KEY: underlined

Qn. 2.1

2.1 Which of the following statements about Rutherford's scattering experiment is/are correct ?

(1) Thin gold foil was used so that each α particle would most likely be scattered by one gold nucleus only.
(2) If β particles were directed towards the gold foil instead of α particles, they could be deflected by both the gold nuclei and the electrons in the foil.
(3) Gold foil was used because gold contains free electrons.

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

favourable distractor

A B C D

Answer : C (28.4%)
Best distractor: A (38.9%)
Many candidates did not understand alpha particles being more massive is the key of the theory behind scattering experiment. They therefore failed to apply the concept to an unfamiliar case of beta particles.

Qn. 2.3

2.3 The figure below shows the emission lines of the hydrogen spectrum associated with electron transitions from excited energy levels to the ground state (n = 1). It is known that the energy level of the ground state is $E_1 = -13.6$ eV.

Which statement is correct ?

A. Spectral line X has the highest frequency.
B. The shortest wavelength of the lines in this spectral series is about 90 nm.
C. These spectral lines are in the infra-red region.
D. Some of these lines also appear in other spectral series of the hydrogen spectrum.

favourable distractor

A B C D

Answer : B (26.5%)
Best distractor: D (33.6%), A (29.4%)
Not many candidates were able to find the correct wavelength corresponding to an energy change of 13.6 eV.
It is worth to note that 1/3 of the candidates thought that the spectra of n=1, n=2 etc. have common lines.

Qn. 2.4

2.4 Which statements about the Bohr atom model are correct ?

(1) It can explain why α particles can be rebounded by a thin gold foil.
(2) It can give the atomic spectra of a singly ionized helium atom (He^+).
(3) A postulate of this model is that the angular momentum of the electron in an hydrogen atom is quantized.

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

favourable distractor

A B C D

Answer : D (22.9%)
Best distractor: B (42.1%)
Many candidates did not know that Bohr model can be applied to any single-electron atom or ion. They were not familiar with the reason behind the formula $-\frac{1}{n^2}\frac{m_e q_e^4}{8h^2\varepsilon_0^2}$.

Qn. 2.8

2.8 Which of the following statements about materials in **bulk form** and in **nano size** are correct ?

(1) Most materials exhibit different colour in the states mentioned above.
(2) Most materials in nano size have lower melting point.
(3) Materials in nano size are usually more efficient in serving as catalyst.

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

favourable distractor

Answer : D (32.0%)
Best distractor: B (43.6%)
Many candidates did not know melting point depression effect of nanoscale materials.

Q.2 Structural question

In order to demonstrate photoelectric effect, the electrodes *A* and *C* of the photocell in Figure 2.1 are connected to a potential difference *V* which can be read from the high-resistance voltmeter. This potential difference can vary from 0 V to 2.5 V.

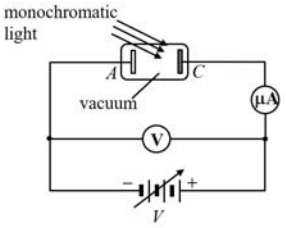


Figure 2.1

When monochromatic light of wavelength 300 nm is incident on electrode *C*, the microammeter of negligible internal resistance shows a reading.

Q.2 Structural question

(a) (i) State the part of the electromagnetic spectrum (ultra-violet, blue, green, red or infra-red) that the incident light belongs to. (1 mark)

(ii) According to wave theory, there should be a 'time delay' for photoelectric emission to occur. However, the experimental result shows that photoelectric emission is immediate. State the implication of such an experimental result. (1 mark)

(a)	(i)	ultra-violet (UV)	1A 1
	(ii)	Light (energy) is (transferred to electrons of the cathode) in packets or quanta (i.e. quantized).	1A 1

In (a)(ii), most candidates misunderstood the question. Instead of giving the **implication** of the experimental result, they tried to explain why there is such a result. Some candidates' explanation was not precise or not relevant, such as **one-to-one process**.

Q.2 Structural question

(b) The applied potential difference is adjusted until the microammeter reading just falls to zero when $V = 1.7$ V.

(i) State and explain whether the microammeter reading would change if an incident light of the same wavelength but higher intensity is used. (2 marks)

(ii) Calculate the work function, in eV, of electrode *C*. (3 marks)

(b)	(i)	Microammeter reading remains zero, energy *E* of incident photons remains unchanged, although intensity ↑ causing more photons incident but no effect on maximum KE of the electrons emitted or on photoemission.	1A 1A 2

For (b)(i), some candidates also misunderstood the question. They did not answer the question based on the voltage = 1.7 V. Many said that the current increases as there are more photons, i.e. the situation before the voltage is set to 1.7 V.

Q.2 Structural Question

(ii) Energy of photon $= \frac{hc}{\lambda}$

$= \frac{(6.63\times10^{-34})(3\times10^{8})}{300\times10^{-9}}$ — 1M

$= 6.63 \times 10^{-19}$ J

$= 4.14375$ (eV) ≈ 4.14 (eV)

Work function $\Phi = 4.14 - 1.7$ — 1M

$= 2.44375$ (eV) ≈ 2.44 (eV) — 1A

3

Performance of (b)(ii) is satisfactory. Common mistakes:

- some candidates simply took the photon energy *hf* as the work function.
- some candidates had difficulties in conversion between joule and eV.

Q.2 Structural question

(c) Now the applied potential difference is adjusted until $V =$ 0.8 V and the microammeter registers 0.4 μA.

(i) Estimate the number of photoelectrons reaching electrode A in one second. (1 mark)

(ii) State the maximum kinetic energy, in eV, of the photoelectrons reaching A. Explain why not all photoelectrons reaching A possesses this amount of kinetic energy. (2 marks)

(c) (i) No. of photoelectrons reaching A in 1 s

$= \frac{0.4\times10^{-6}}{1.6\times10^{-19}} = 2.5\times10^{12}$ — 1A

1

Performance in (c)(i) is fair. Some candidates did not realise the number of photoelectrons can be directly found from the current given. They tried to find the answer by photon energy, work function, etc., which is indeed not possible.

Q.2 Structural Question

(ii) 1.7 – 0.8 = 0.9 (eV) or 4.14 – 2.4 – 0.8 = 0.94 (eV). — 1A

Electrons inside cathode C (not on surface) need an amount of energy more than the work function to escape / be emitted from C. — 1A

2

For first 1A, many candidates did not have a solid concept about the meaning of different energies. Even though the answer can be obtained simply by subtracting the two values given, they cannot figure out the correct way to find the answer.

For second 1A:

- Some candidates thought the variation is caused by things happen when the photoelectrons move from cathode to anode (rather than the process when electrons escape from the metal surface).
- Some other candidates employed the concept in Bohr model of hydrogen atom to explain what happens in metal.

HKDSE 2020
Physics Paper 2

Section D:
Medical Physics

Multiple Choice Questions

Qn	1	2	3	4	5	6	7	8
A	9%	13%	5%	46%	16%	15%	24%	37%
B	20%	14%	28%	13%	43%	3%	55%	36%
C	12%	59%	8%	27%	29%	76%	5%	13%
D	59%	14%	59%	14%	12%	6%	16%	14%

KEY: underlined

Qn. 4.4

Which of the following statements about the piezoelectric crystal inside an ultrasound transducer is/are correct ?

(1) The piezoelectric crystal converts electrical signals into mechanical vibrations and vice versa.

(2) The thickness of the piezoelectric crystal is arbitrary.

A.*	46%	Only (1) is correct.
B.	13%	Only (2) is correct.
C.	27%	(1) and (2) are correct.
D.	14%	(1) and (2) are incorrect.

favourable distractor

Qn. 4.5

Using the information given below, find the proportion of energy transmitted when ultrasound is incident from air to skin.

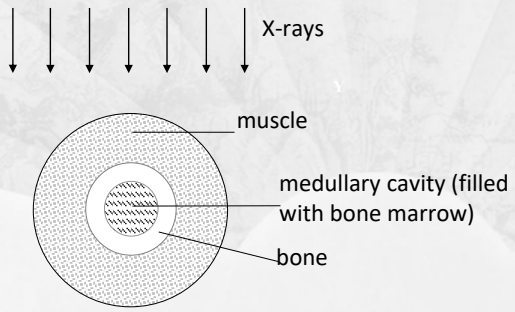
	acoustic impedance / kg m^{-2} s^{-1}
air	430
soft tissue	1.5×10^6

A.	16%	5.7×10^{-4}
B.*	43%	1.1×10^{-3}
C.	29%	2.8×10^{-3}
D.	12%	1.0×10^{-2}

favourable distractor

Qn. 4.8

The figure shows a simplified diagram of the cross-section of human arm. The medullary cavity is the central cavity that is filled with bone marrow. The linear attenuation coefficient of bone marrow is roughly the same as that of muscle.



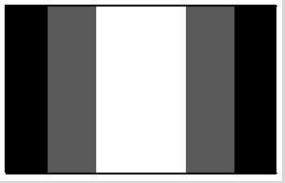
Qn. 4.8

Which figure below best represents the X-ray radiographic image of the arm ?

favourable distractor

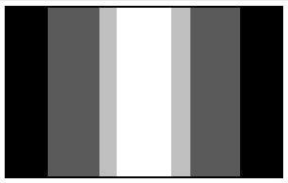
A.* 37%

B. 36%



C. 13%

D. 14%



Q.4(a)

(a) State briefly how X-rays are produced.

a) X射線是通過電子高速撞擊重金屬靶，電子失去動能後放射出的輻射。 ✓

電壓的一端釋出電子撞击另一端的金屬板，從而產生X射線。 ✗

X 射線是波長極短的波，透過電訊號轉換為超聲波。 ✗

利用X粒子撞击金屬板 ✗

Q.4(a)

X-rays are produced by fast-moving electrons hitting a heavy metal target. ✓

Fast moving electrons hit the metal, X-rays are produced. ✗

X-rays is produced by rapid deceleration of electrons to the metal pads. ✗

Q.4(b)(i)

(b)The table below shows the linear attenuation coefficients of soft tissue and bone for an X-ray beam.

	linear attenuation coefficient
soft tissue	$\mu_s = 0.51\ cm^{-1}$
bone	$\mu_b = 2.46\ cm^{-1}$

(i) State one factor contributing to a higher linear attenuation coefficient of bone compared to soft tissue. (1 mark)

Q.4(b)(i)

Because bone has higher density than soft tissue which cannot pass through easily. ✓

higher density ✓

因為骨的密度較高。✓

因輻射難以穿透入骨。 ✗

There are many small holes in bone ✗

Bones are mainly solid, there is nearly no gas in it, so it attenuates X-ray more than soft tissues which are often containing many gas and liquid inside. ✗

Q.4(b)(ii)

(b)The table below shows the linear attenuation coefficients of soft tissue and bone for an X-ray beam.

	linear attenuation coefficient
soft tissue	$\mu_s = 0.51\ cm^{-1}$
bone	$\mu_b = 2.46\ cm^{-1}$

(ii) X-ray beam of intensity I_0 passes through soft tissue that is 5.6 cm in thickness and is attenuated to intensity I. What thickness of bone would yield the same degree of attenuation of the same X-ray beam ? Show your calculation. (2 marks)

Q.4(b)(ii)

(ii) $I_0 e^{-0.51(5.6)} = I_0 e^{-2.46x}$ ✓

$-0.51(5.6) = -2.46x$

$x = 1.16\ cm$

Thickness of bone is 1.16cm

$-2.856 = -2.46x$ ✓

$x = 1.16$

$\therefore$ 1.16 cm.

(ii) Bone half value thickness:

$\frac{\ln 2}{0.51}$ $\frac{\ln 2}{2.46} = 0.282\ cm$

Soft Tissue half value thickness:

$\frac{\ln 2}{0.51} = 1.36\ cm$

$I = I_0 (\frac{1}{2})^{\frac{5.6}{1.36}} = 0.0574\ I_0$ ✓

$0.0574\ I_0 = I_0 (\frac{1}{2})^{\frac{x}{1.36}}$

$x = 1.16\ cm$

$5.6(0.51) = X(2.46)$

$X = 1.16097$

設 X = 骨厚度.

骨 = 1.16 cm 厚。 ✓

Q.4(b)(ii)

Let x be the thickness of bone.

$\frac{0.51}{2.46} = \frac{5.6}{x}$ ✗

$x = 27.0\ cm$ (3 S.F.)

By $I = I_0 e^{-\mu x}$

$I = I_0 e^{-(0.51)(5.6)}$

= ✗

(ii) $\sqrt{0.51} = \frac{(I_0 - 5.6)^2}{(I_0 + 5.6)^2}$

$\sqrt{0.51} = \frac{I_0 - 5.6}{I_0 + 5.6}$

$I_0 = 33.2$

$2.46 = \frac{(33.2 - I)^2}{(33.2 + I)^2}$

$I = -7.35$ ✗

Q.4(b)(iii)

(ii) Explain why X-ray radiographic imaging of the breast usually employs X-rays of lower energy (~20 keV) while examination of bony structures employs X-rays of energy around 100 keV. (2 marks)

因為乳房是軟組織，低能量X射線足已足以穿透並成像，含骨結構則因骨質密度較高的X射線才能清晰成像。

(iii) 因為乳房的軟組織較多，线衰減係數較小，所以只需采用較弱的X-射线就可以穿透，而含骨骼的結构线衰減係數較大，只有較強的X-射线才能穿透并完成成像。

Q.4(b)(iii)

4(b)(iii) Because lung in chest mainly consist of air which has low linear attenuation coefficient. However, in ~~body~~ bony structures, they are mainly bones which have high linear attenuation coefficient. Therefore, a lower energy X-ray can be use for chest while a higher energy X-ray is used for bony ~~area~~ structures to ensure the emerging X-ray has enough intensity to blacken the X-ray film.

Because breast has lower linear attenuation coefficient than bone, thus more X-ray will be detected by X-ray detector (after passing through breast) than that of bone. More X-ray is attenuated in bone than in breast. Thus more energy is needed to ensure that there will be X-ray not attenuated that will blacken the film to give the X-ray film of the structure.

Q.4(b)(iii)

(iii) 因乳房的线衰減係數較低，只需用能量低的X射線就能檢查。但骨骼的線衰減係數高，必須用能量較高的X射線才能穿透檢查。

因為骨骼的線衰減係數較乳房（主要為軟組織）的高很多，如果用 ~~a~~ ~20keV的 X-射線檢查骨骼，會因衰減過多而不見效果。

(iii) 因為低能量的X-射線的軸向解像度較高，而適合檢查近皮膚表的組織；而高能量的X-射線橫向解向度較高，適合體表深處的組織檢查。

Q.4(b)(iii)

Because the higher energy can provide a longer wavelength. Bone required longer wavelength to pass through, but the breast don't.

As the breast is filled with fat which is less dense than the bone. Therefore the X-ray radiographic imaging could capture the reflection even with lower energy.

Breast has a lower attenuation than bone, so it only needs lower energy X-Rays, while bony structure need a high energy X-Ray to see clearly.

Q.4 (c)

People are often concerned about the radiation exposure during medical examinations like X-ray radiographic imaging and computed tomography (CT) scans. Some information about the radiation dose is given below:

Source / item	Equivalent dose
Taking an X-ray radiographic image	0.1 – 0.2 mSv
A CT scan	1 – 10 mSv
Average weekly natural background dose for a person	about 0.05 mSv

Q.4(c)

(i) State one potential hazard of exposure to ionizing radiation on human bodies. (1 mark)

(ii) Explain why the equivalent dose of a CT scan is higher than that of taking an X-ray radiographic image. (2 marks)

(iii) Name one source contributing to the natural background dose. (1 mark)

Q.4(c)(i)

It may ionize body cell and cause cancer ✓

Human bodies may develop cancer cells due to mutation ✓

The ionizing radiation may harm the other organs in the body. ✗

The body parts of the human may be ionized causing the breakage of body parts become easy. ✗

It may cause radiation sickness. ✗

Q.4(c)(i)

使細胞變異，引發癌症 ✓

患上癌症。 ✓

增加患上癌症的風險。

致癌。 ✓

因為致電離輻射令基因突變細胞 ✗

DNA 變異。 ✓

吸收過多輻射，危害身体器官. ✗

致電離輻射會殺死人體活性組織。 ✗

Q.4(c)(ii)

(ii) Explain why the equivalent dose of a CT scan is higher than that of taking an X-ray radiographic image. (2 marks)

CT scan take multiple X-ray image at different angle. ✓

A CT scan involves multiple X-ray scans as it is used to create 3D images so it scans in multiple dimensions. ✓

CT scan is multiple X-ray radiographic images. As more X-ray radiographic images are taken, equivalent dose of CT scan is higher. ✓

A CT scan is stitching together a lot of X-Ray scans into a 3D projection ✓

It is because CT scan can show clearer images and there are more details because it is newer than X-ray. ✗

Q.4(c)(ii)

(ii) 因CT掃描需要圍繞人體照射X射線，獲取三維圖像。X射線是投射攝影成像不需要。 ✓

因CT掃描需時較長，而越長時間進行掃描，吸收到的輻射亦較多，等效劑量亦較高。 ✓

因為CT掃描是大範圍且精度較高的成像掃描掃描方法。 ✗

因為CT扫描属于二维成像，而X射线出来的像是一维，所以需要更多的等效剂量。 ✗

Q.4(c)(iii)

(iii) Name one source contributing to the natural background dose. (1 mark)

The radiation by the light. ✗

Concrete ✗

Sunlight ✗

Radon gas released from ground. ✓

radio wave of the phone ✗

Electronic devices. ✗

cosmic rays from space ✓

Cosmic radiation from interspace. ✓

Sun which radiates UV light. ✗

the dose from rocks. ✗

Space radiation ✗

Q.4(c)(iii)

食物所發出的輻射. ✗

紅外线輻射. ✗

宇宙輻射. ✗

太陽。 ✗

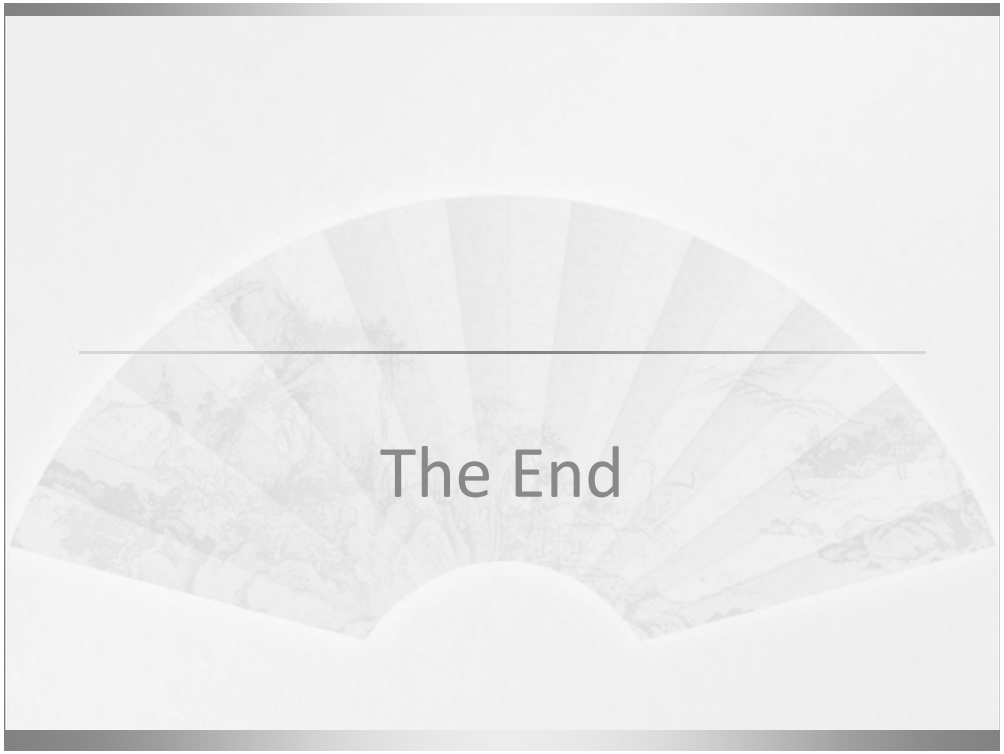
水 ✗

宇宙的背景輻射 ✗

食物。 ✗

宇宙射線，如太陽的輻射 ✗

由太陽發出的紫外輻射。 ✗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