2022-DSE
PHY
PAPER 2

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Candidate Number									

HONG KONG EXAMINATIONS AND ASSESSMENT AUTHORITY
HONG KONG DIPLOMA OF SECONDARY EDUCATION EXAMINATION 2022

PHYSICS PAPER 2

Question-Answer Book

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

INSTRUCTIONS

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

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

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

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

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

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

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

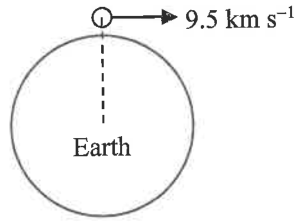
(8) No extra time will be given to candidates for sticking on the barcode labels or filling in the question number boxes after the 'Time is up' announcement.

* A 1 5 0 E 2 M C *

Section A : Astronomy and Space Science

Q.1: Multiple-choice questions

1.1 The minimum velocity for an object to keep orbiting the Earth is 7.9 km s^{-1}, whereas the escape velocity is 11.2 km s^{-1}.

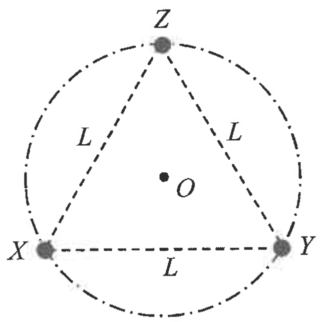


What kind of orbit would an object travel if it is launched horizontally with a velocity of 9.5 km s^{-1} ? Assume that the atmospheric drag is negligible.

A. circular orbit
B. elliptical orbit
C. parabolic orbit
D. along a straight line

A ○ B ○ C ○ D ○

1.2



Three identical stars X, Y and Z are situated at the vertices of an equilateral triangle of side length L. They perform uniform circular motions with angular velocity ω about the centre O of the triangle. Which of the following is the relationship between ω and L ?

A. $\omega \propto \sqrt{\frac{1}{L^3}}$

B. $\omega \propto \sqrt{L^3}$

C. $\omega \propto \sqrt{\frac{1}{L}}$

D. $\omega \propto \sqrt{L}$

A ○ B ○ C ○ D ○

1.3 A satellite initially at rest is launched from the Earth's surface into an orbit at a height R above the Earth's surface in which the satellite performs uniform circular motion, where R is the radius of the Earth. The gain in kinetic energy of the satellite in this process is K. What is the corresponding change in the satellite's gravitational potential energy ?

A. $-2K$
B. $-K$
C. $+2K$
D. $+K$

A ○ B ○ C ○ D ○

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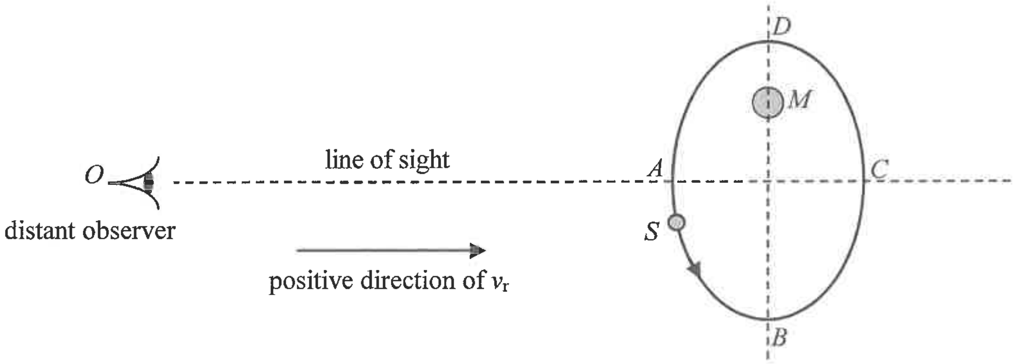
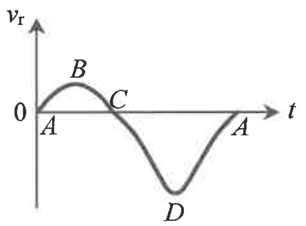
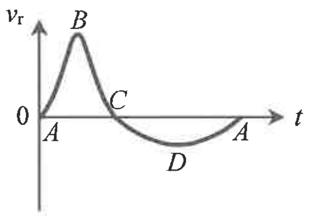
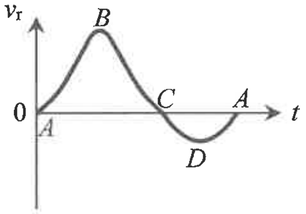
1.4 In the binary star system shown below, star M is a massive star which is nearly stationary. Star S moves around M in an elliptical orbit with major axis BD.

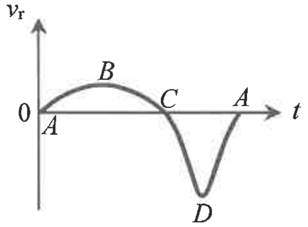


A distant observer O is in the orbital plane of star S, with the line of sight perpendicular to BD. Which graph below best shows the variation of the observed radial velocity v_r of S with time t ? S travels in an anticlockwise direction A-B-C-D-A and its positions A, B, C and D are marked correspondingly on the graphs.

A.


B.


C.


D.


A B C D
○ ○ ○ ○

1.5 In the same star cluster, a blue star and a red star have the same apparent magnitude. What is the ratio $\frac{\text{radius of blue star}}{\text{radius of red star}}$ if the surface temperature of the blue star is twice that of the red star ?

A. 1 : 4
B. 1 : 2
C. 2 : 1
D. 4 : 1

A B C D
○ ○ ○ ○

1.6 Two distant stars X and Y have the same absolute magnitude but X appears 4 times as bright as Y to the naked eye. What is the ratio of the stellar parallax of X to that of Y ?

A. 1:4
B. 1:2
C. 2:1
D. 4:1

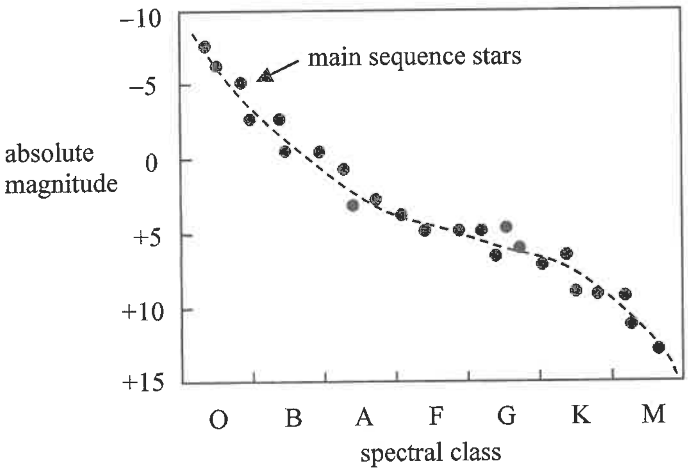
A B C D
○ ○ ○ ○

1.7 The calcium H line (396.8 nm) from a distant object appears to be at 395.8 nm in the absorption spectrum observed. From this information, one can conclude that the object moves

A. towards the Earth at a speed of 756 km s^{-1}.
B. away from the Earth at a speed of 756 km s^{-1}.
C. towards the Earth at a speed of at least 756 km s^{-1}.
D. away from the Earth at a speed of at least 756 km s^{-1}.

A B C D
○ ○ ○ ○

1.8 The Hertzsprung-Russell (H-R) diagram below shows a series of main sequence stars.



The properties of three main sequence stars X, Y and Z are tabulated below. Which of them is/are farther than 10 pc from the Earth ?

star	apparent magnitude	spectral class
X	0	F
Y	5	B
Z	4	K

A. X only
B. Y only
C. X and Z only
D. Y and Z only

A B C D
○ ○ ○ ○

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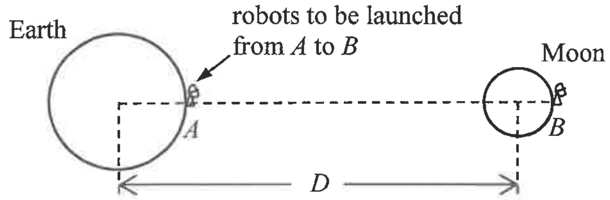
Q.1: Structured question

Given: mass of the Moon = 0.0123 × mass of the Earth
radius of the Moon = 0.273 × radius of the Earth

(a) Based on Newton's universal law of gravitation, estimate the ratio of gravitational acceleration on the Moon's surface, g_M, to that on the Earth's surface, g_E. Give your answer correct to 3 significant figures. (2 marks)

(b) Scientists plan to deploy robots to the far side of the Moon to build radio telescopes for observing electromagnetic waves (EM waves).

Figure 1.1

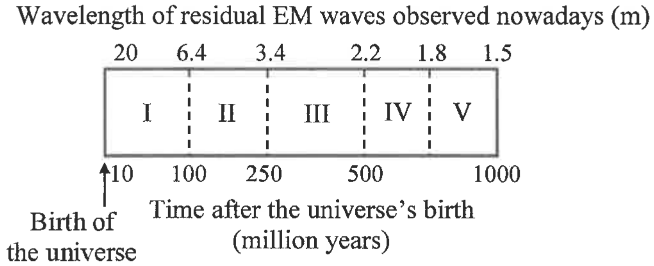


(i) At a certain point N between the Earth and the Moon, the gravitational forces due to the Earth and the Moon balance each other. Estimate the distance of N **from the Earth's centre** in terms of the average Earth-Moon separation D. (2 marks)

(ii) For launching an object from point A on the Earth's surface so that it eventually reaches the Moon, the object must possess enough energy to reach point N. Estimate the minimum launching velocity of the robot. Given: the change in gravitational potential energy of an object from A to N in the Earth-Moon system is 6.12×10^7 J kg^{-1}. (2 marks)

(c) Our universe is estimated to be 14 billion (i.e. 14000 million) years old. Scientists discovered that hydrogen atoms in the early universe (i.e. 0.4 to 1000 million years since its birth) have been emitting EM waves of wavelength 21 cm. As the universe has been expanding over time, these residual EM waves that we observe nowadays have their wavelengths stretched to different extents depending on when the EM waves were produced (see Figure 1.2).

Figure 1.2



(i) Name the phenomenon of the 'stretching' of wavelengths as mentioned above. (1 mark)

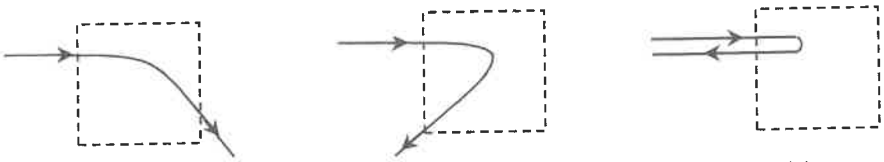
(ii) The radio telescope in (b) for observing these residual EM waves covers a range of frequencies including f_c = 20 MHz. Determine the wavelength λ_c of the EM waves corresponding to f_c and name this kind of EM waves. (2 marks)

(iii) Referring to Figure 1.2, identify the period (I to V) that the EM waves in (c)(ii) comes from. (1 mark)

Section B : Atomic World

Q.2: Multiple-choice questions

2.1



Each of the above figures shows the path of an α particle scattered by a fixed charged particle P (**NOT** shown in the figure but inside the dotted region). If electrostatic force is the only interaction between the two particles, from which figure can one deduce that P **must be** positively charged ?

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

A B C D
○ ○ ○ ○

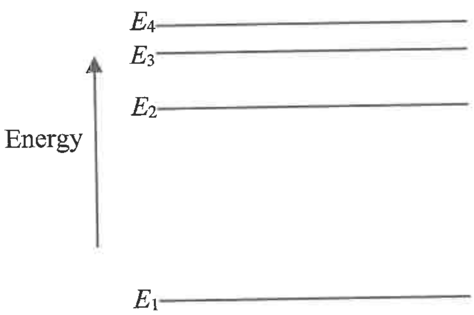
2.2 Which statements below about the **absorption spectrum** of helium are correct ?

(1) Helium atoms can only absorb photons with energy that equals the difference between two energy levels of helium.
(2) The dark lines in the absorption spectrum of helium match those in its emission spectrum.
(3) The dark lines in the spectrum correspond to the wavelength of photons being absorbed by helium atoms.

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

A B C D
○ ○ ○ ○

2.3 The diagram represents the energy levels **drawn to scale** for an electron in a certain atom. The electron transition from E_3 to E_1 produces a green line. What electron transition would give rise to a red line ?
Given: the visible spectrum is about 400 nm to 750 nm



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

A B C D
○ ○ ○ ○

Please stick the barcode label here.

2.4 According to the Bohr model of the hydrogen atom, which of the following physical quantities about the electron of the atom will decrease when a photon is emitted from the hydrogen atom ?

(1) the orbital radius of the electron
(2) the angular momentum of the electron
(3) the kinetic energy of the electron

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

A B C D
○ ○ ○ ○

2.5 An optical microscope is employed to view a specimen such that two points of separation 3×10^{-6} m can just be resolved. If the diameter of the objective lens is 10 mm, deduce a probable combination of objective-to-specimen separation L and wavelength λ of the light used.

	L / cm	λ / nm
A.	5	410
B.	4	615
C.	3	410
D.	2	615

A B C D
○ ○ ○ ○

2.6 A voltage V_0 is applied to the anode of a transmission electron microscope (TEM) in order to produce an electron beam of de Broglie wavelength 0.01 nm. What should the anode voltage be for reducing the wavelength to 0.005 nm ?

A. $\frac{V_0}{4}$

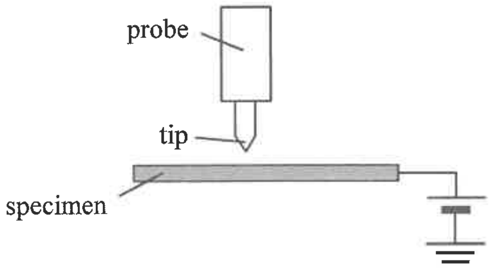
B. $\frac{V_0}{2}$

C. $2V_0$

D. $4V_0$

A B C D
○ ○ ○ ○

2.7 The simplified schematic diagram below shows a scanning tunnelling microscope (STM).



Which of the following statements about its operation is/are correct ?

(1) The tunnelling current increases with the conductivity of the specimen's surface.
(2) The tunnelling current is independent of the medium between the tip and the specimen.
(3) When scanning in the constant height mode, the change in distance between the tip and the specimen's surface is in atomic scale.

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

A B C D
○ ○ ○ ○

2.8 Which of the following is/are in nanoscale ?

(1) the diameter of a human hair
(2) the size of a gold nucleus
(3) the size of a coronavirus (e.g. COVID-19) particle

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

A B C D
○ ○ ○ ○

Please stick the barcode label here.

Q.2: Structured question

When monochromatic light is incident on a metal surface, electrons within a certain range of energies are emitted. Each photon of the monochromatic light carries 4.97×10^{-19} J of energy.

(a) (i) Explain whether the range mentioned above would be affected if the intensity of this monochromatic light is increased. (2 marks)

(ii) Given that the light intensity is 0.050 W m^{-2} and the area of the metal surface is 1.00×10^{-4} m^2, estimate the maximum number of electrons emitted per second. (2 marks)

The metal surface is illuminated by monochromatic lights of different wavelengths λ in turns. The corresponding maximum kinetic energy of the emitted electrons KE_{max} are obtained by measuring the stopping potential V_s. A graph of KE_{max} against λ is plotted as shown in Figure 2.1.

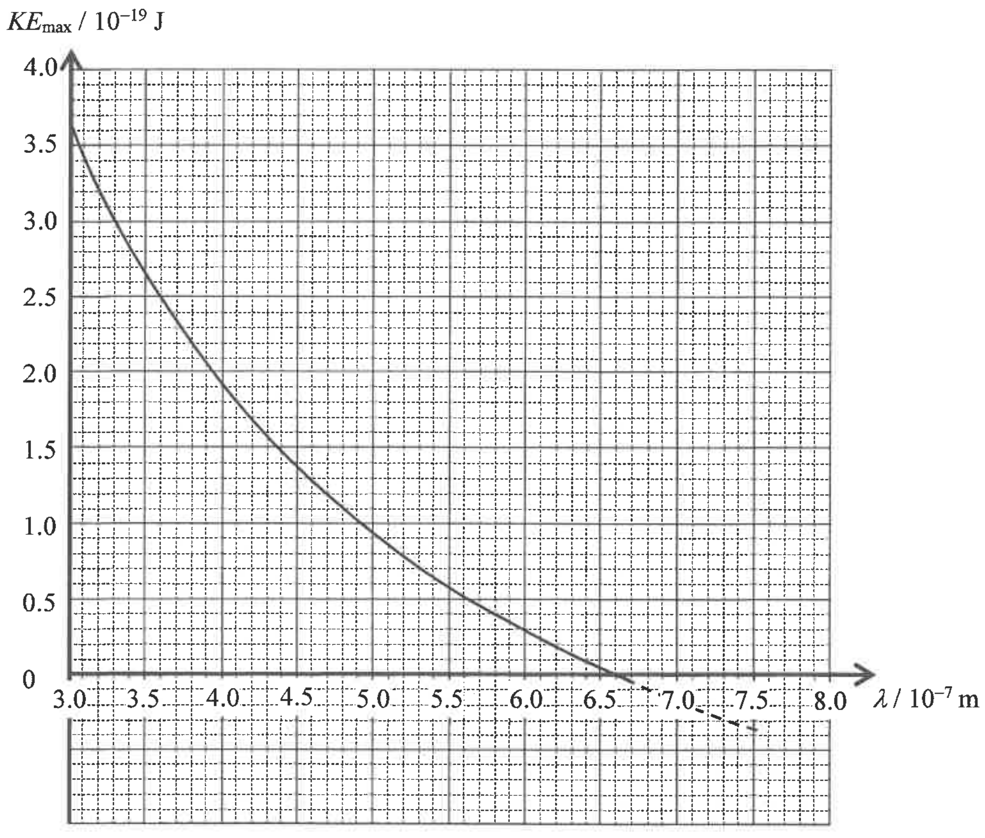


Figure 2.1

(b) If monochromatic light of wavelength 4.0×10^{-7} m is used, find the corresponding stopping potential. (2 marks)

(c) Find the work function, in eV, of the metal. (3 marks)

(d) If another metal with a larger work function is used, would the intercept on the vertical axis increase, decrease or remain unchanged ? (1 mark)

Section C : Energy and Use of Energy

Q.3: Multiple-choice questions

3.1 Three types of lamps, *P*, *Q* and *R*, are available.

lamp	power rating / W	efficacy / lm W^{-1}
P	6	100
Q	8	110
R	10	85

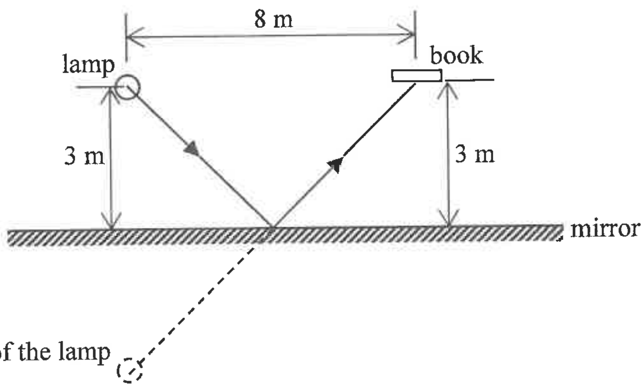
When they operate at their respective ratings under the same conditions, which one is the brightest ? Which one consumes the least amount of energy ?

	brightest	least amount of energy consumed
A.	*Q*	*P*
B.	*Q*	*Q*
C.	*R*	*P*
D.	*R*	*Q*

A B C D

○ ○ ○ ○

3.2 The figure shows a lamp of luminous flux 6000 lm placed 3 m above a horizontal mirror, and a book is placed horizontally at the same height as the lamp. The light from the lamp is reflected from the mirror to the book. If the mirror reflects 100% of the light energy, find the illuminance on the side of the book facing the mirror.



A. 2.9 lx
B. 3.8 lx
C. 4.8 lx
D. 11.5 lx

A B C D

○ ○ ○ ○

3.3 The upper and lower reservoirs of a hydroelectric power plant have a height difference of 80 m in water levels. The turbine of the power plant gives a total output power of 1000 MW. Assuming that the overall efficiency of the hydroelectric power plant is 80%, estimate the water flow rate, in kg s^{-1}, through the turbine.
($g = 9.81$ m s^{-2})

A. 1.02×10^6
B. 1.27×10^6
C. 1.52×10^6
D. 1.59×10^6

A B C D

○ ○ ○ ○

3.4 According to the Energy Efficiency Labelling Scheme (EELS), which statement below about an air-conditioner of grade 1 is correct ?

A. It is more energy efficient than a refrigerator of grade 5.
B. Its electric power consumption must be less than that of an air-conditioner of grade 5.
C. Its energy efficiency must be above the average energy efficiency of air-conditioners in the same category of cooling capacity.
D. Its energy efficiency must be below the average energy efficiency of air-conditioners in the same category of cooling capacity.

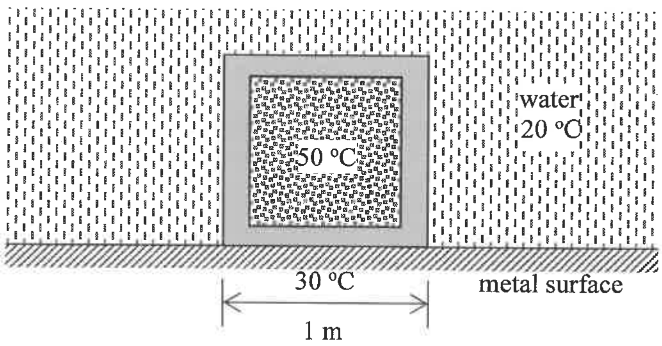
A B C D
○ ○ ○ ○

3.5 The COP (coefficient of performance) of an air-conditioner is 4.0. If it is replaced by another one with the same input power and of COP 6.0, the percentage increase in the **rate of total thermal energy released** to the environment outside is

A. 29 % .
B. 33 % .
C. 40 % .
D. 50 % .

A B C D
○ ○ ○ ○

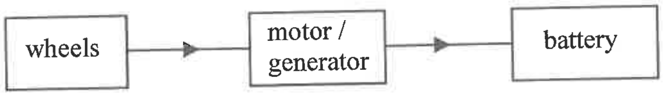
3.6 The figure shows a cubical container of side length 1 m submerged in water of temperature 20 °C and its base rested on a metal surface at 30 °C. The container is filled with a certain liquid at 50 °C. The U-value of the walls of the container is 10 W m^{-2} K^{-1}. Find the rate of thermal energy transferred away from the container at the instant shown.

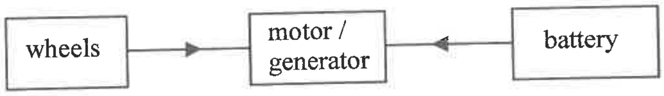


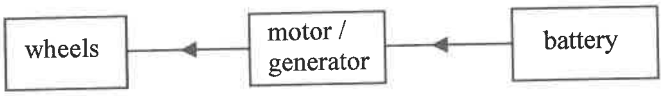
A. 900 W
B. 1100 W
C. 1300 W
D. 1700 W

A B C D
○ ○ ○ ○

3.7 In each of the schematic diagrams below, the arrows represent the directions of power flow in an electric vehicle's power system.

(1) 

(2) 

(3) 

Which diagram most probably corresponds to the situation when the vehicle is (i) accelerating and (ii) braking ?

	accelerating	**braking**
A.	(3)	(2)
B.	(3)	(1)
C.	(1)	(2)
D.	(1)	(3)

A B C D

3.8 What are the factors that determine the power generated by a wind turbine ?

(1) air density
(2) wind speed
(3) length of the turbine blades

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

A B C D

Q.3: Structured question

Mr. Chan plans to install a solar photovoltaic system on the roof of his house for generating electricity domestically.

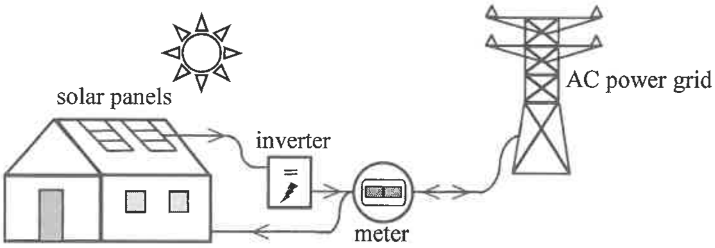
(a) Each solar panel in the system has an area of 1.934 m^2. When it is normal to the Sun, the output voltage and current are 38 V and 10 A respectively on a clear day. Given: the maximum solar power per unit area reaching the Earth's surface is 1000 W m^{-2}

(i) Find the output power of the solar panel and estimate its efficiency. (2 marks)

(ii) In order to achieve a generation capacity of about 10 kW but not exceeding it, find the number of such solar panels to be installed and the corresponding minimum roof area required. (2 marks)

(b) Mr. Chan can take part in the 'Feed-in Tariff (FiT) Scheme' by connecting his solar photovoltaic system to the power grid of the power company via an inverter as shown in Figure 3.1. The renewable energy generated can then be sold to the power company.

Figure 3.1



(i) Why an inverter is needed to be installed between the solar panels and the AC power grid ? (1 mark)

(ii) Throughout a year, Hong Kong has a daily average of 4.5 effective sunshine hours. Estimate the maximum energy, in kW h, that a solar photovoltaic system of 10 kW generation capacity can deliver in one year. (1 mark)

(iii) Suggest the main reason why the actual amount of electrical energy generated is far less than the value estimated in (b)(ii). (1 mark)

(iv) Given: the FiT Scheme offers a rate of \$5 per kW h for a renewable energy system of capacity which does not exceed 10 kW and at most 10000 kW h of the renewable energy generated can be sold to the power company per year. If the initial construction cost of such a system is \$200000 and the maintenance cost is \$5000 per year, estimate the number of years it would take to recover the investment capital. (2 marks)

(c) State one advantage of solar photovoltaic systems over wind power systems for domestic generation. (1 mark)

Section D : Medical Physics

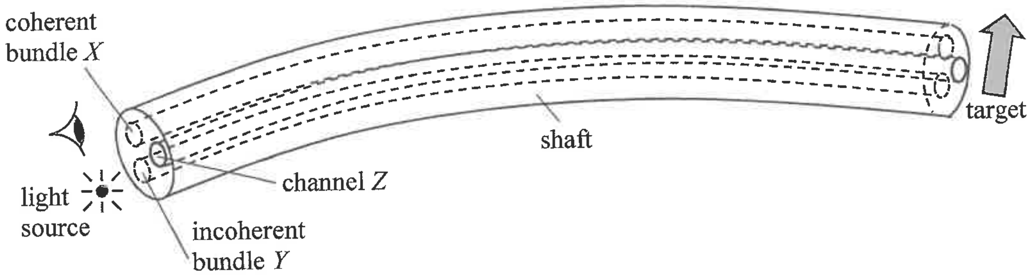
Q.4: Multiple-choice questions

4.1 Sam suffers from short sight and needs a pair of spectacles of −1.5 D to correct his far point to the normal position. One day he breaks his spectacles. He finds a pair of spectacles of −1.25 D that he used to wear. How far is he able to see clearly with this pair of spectacles ?

A. 0.25 m from the eyes
B. 0.68 m from the eyes
C. 4 m from the eyes
D. 7.5 m from the eyes

A B C D
○ ○ ○ ○

4.2 The figure shows a fibre optic endoscope with two bundles of optical fibres X and Y. The coherent bundle X is for image transmission while the incoherent bundle Y is for transmitting light to illuminate the target. Z is a channel through the shaft of the endoscope.



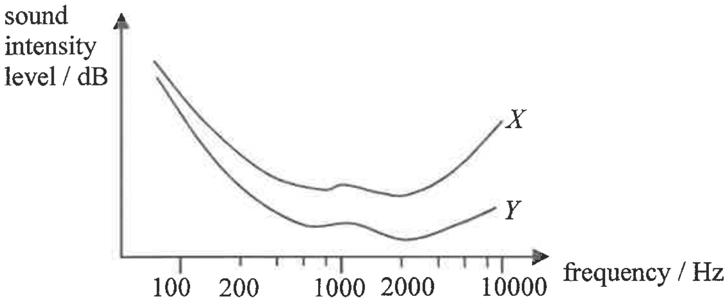
Which of the following statements is/are correct ?

(1) Bundle X cannot be used to transmit light for illumination.
(2) Bundle Y cannot be used to transmit images.
(3) Tools can be inserted through channel Z to take tissue samples for medical testing.

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

A B C D
○ ○ ○ ○

4.3 The figure below shows the threshold-of-hearing curves of a person with normal hearing and an old man suffering from hearing loss.



Which of the following statements is/are correct ?

(1) Curve Y belongs to the old man.
(2) The old man's ears are most sensitive to sound at around 2000 Hz.
(3) The old man's hearing loss is more severe for low frequency sounds.

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

A B C D

4.4 An 8-hour exposure to a sound intensity level of 90.0 dB may cause hearing loss. How much energy falls on an eardrum of area 0.503 cm^2 for such exposure ? Given: intensity of threshold of hearing is 10^{-12} W m^{-2}

A. 1.45 J
B. 1.45×10^{-3} J
C. 1.81×10^{-4} J
D. 2.42×10^{-5} J

A B C D

4.5 Which statement below about **acoustic impedance** of a material to ultrasound is correct ?

A. It represents how much resistance an ultrasound beam encounters as the beam passes through the material.
B. Its value increases with the mass of the material.
C. Its value depends on the frequency of the ultrasound.
D. A perfect reflection occurs at a boundary with two tissues having the same acoustic impedance.

A B C D

4.6 When an ultrasound scanner is used to examine a large organ, the ultrasound must be able to reach locations deep inside the body. Which of the following can help achieve this purpose ?

(1) applying a layer of coupling gel to the skin to fill up the air gap between the transducer and the skin
(2) using a transducer employing ultrasound of a lower frequency
(3) using a transducer with a higher resolving power

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

A B C D
○ ○ ○ ○

4.7 The linear attenuation coefficients of soft tissue for X-rays of 20 keV and 60 keV are 0.77 cm^{-1} and 0.21 cm^{-1} respectively. Determine the intensity ratio of 20 keV to 60 keV X-ray beams transmitted respectively through soft tissue of thickness 20 cm. Assume that both X-ray beams have the same initial intensity.

A. 2.1×10^{-7}
B. 7.1×10^{-6}
C. 1.4×10^{-5}
D. 1.5×10^{-2}

A B C D
○ ○ ○ ○

4.8 The typical **total scan and image processing time** for computed tomography (CT), radionuclide image (RNI) and X-ray radiography (XP) in ascending order is

A. RNI < CT < XP .
B. XP < RNI < CT .
C. CT < XP < RNI .
D. XP < CT < RNI .

A B C D
○ ○ ○ ○

Q.4: Structured question

(a) The table below shows some information of air, skin and muscle.

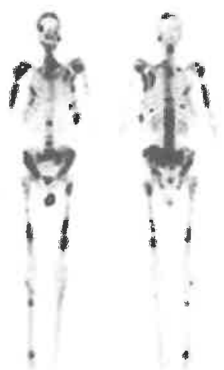
	density (kg m^{-3})	speed of sound (m s^{-1})
air	1.20	340
skin	1000	1520
muscle	1040	1630

(i) Find the acoustic impedance of muscle. (1 mark)

(ii) An ultrasound transducer is inclined at 5° to the normal of the skin surface when it is used for a scan. Find the angle of refraction of the ultrasound beam after it enters the skin from the air. (2 marks)

(iii) Hence explain why an ultrasound transducer should be held perpendicular to the skin surface during a scan. (2 marks)

(b) Figure 4.1(a) is a radionuclide image showing the bone scan of a patient. Figure 4.1(b) shows a chest X-ray image of a person.



Front Back

Figure 4.1(a)

Figure 4.1(b)

(i) In terms of **nature of radiation source** and **image production mechanism**, compare how the images in Figure 4.1(a) and Figure 4.1(b) are produced. No need to mention the instruments for detection and their detecting mechanisms. (3 marks)

(ii) Radionuclide imaging is able to provide information that X-ray radiographic imaging cannot. Explain briefly. (2 marks)

END OF PAPER

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

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Answers written on this page will not be marked.

List of data, formulae and relationships

Data

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

Rectilinear motion

For uniformly accelerated motion :

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

Mathematics

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

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

Astronomy and Space Science

$U = -\frac{GMm}{r}$	gravitational potential energy
$P = \sigma A T^4$	Stefan's law
$\left\|\frac{\Delta f}{f_0}\right\| \approx \frac{v}{c} \approx \left\|\frac{\Delta\lambda}{\lambda_0}\right\|$	Doppler effect

Energy and Use of Energy

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

Atomic World

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

Medical Physics

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

A1. $E = mc\,\Delta T$ — energy transfer during heating and cooling

A2. $E = l\,\Delta m$ — energy transfer during change of state

A3. $pV = nRT$ — equation of state for an ideal gas

A4. $pV = \frac{1}{3}Nm\overline{c^2}$ — kinetic theory equation

A5. $E_K = \frac{3RT}{2N_A}$ — molecular kinetic energy

B1. $F = m\frac{\Delta v}{\Delta t} = \frac{\Delta p}{\Delta t}$ — force

B2. moment $= F \times d$ — moment of a force

B3. $E_P = mgh$ — gravitational potential energy

B4. $E_K = \frac{1}{2}mv^2$ — kinetic energy

B5. $P = Fv$ — mechanical power

B6. $a = \frac{v^2}{r} = \omega^2 r$ — centripetal acceleration

B7. $F = \frac{Gm_1m_2}{r^2}$ — Newton's law of gravitation

C1. $\Delta y = \frac{\lambda D}{a}$ — fringe separation in double-slit interference

C2. $d\sin\theta = n\lambda$ — diffraction grating equation

C3. $\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$ — equation for a single lens

D1. $F = \frac{Q_1Q_2}{4\pi\varepsilon_0 r^2}$ — Coulomb's law

D2. $E = \frac{Q}{4\pi\varepsilon_0 r^2}$ — electric field strength due to a point charge

D3. $E = \frac{V}{d}$ — electric field between parallel plates (numerically)

D4. $R = \frac{\rho l}{A}$ — resistance and resistivity

D5. $R = R_1 + R_2$ — resistors in series

D6. $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$ — resistors in parallel

D7. $P = IV = I^2R$ — power in a circuit

D8. $F = BQv\sin\theta$ — force on a moving charge in a magnetic field

D9. $F = BIl\sin\theta$ — force on a current-carrying conductor in a magnetic field

D10. $B = \frac{\mu_0 I}{2\pi r}$ — magnetic field due to a long straight wire

D11. $B = \frac{\mu_0 NI}{l}$ — magnetic field inside a long solenoid

D12. $\varepsilon = N\frac{\Delta\Phi}{\Delta t}$ — induced e.m.f.

D13. $\frac{V_s}{V_p} \approx \frac{N_s}{N_p}$ — ratio of secondary voltage to primary voltage in a transformer

E1. $N = N_0 e^{-kt}$ — law of radioactive decay

E2. $t_{\frac{1}{2}} = \frac{\ln 2}{k}$ — half-life and decay constant

E3. $A = kN$ — activity and the number of undecayed nuclei

E4. $\Delta E = \Delta mc^2$ — mass-energy relationship