2021-DSE
PHY

PAPER 2

HONG KONG EXAMINATIONS AND ASSESSMENT AUTHORITY

HONG KONG DIPLOMA OF SECONDARY EDUCATION EXAMINATION 2021

PHYSICS PAPER 2

Question-Answer Book

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

Please stick the barcode label here.

Candidate Number									

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.

A150E2MC

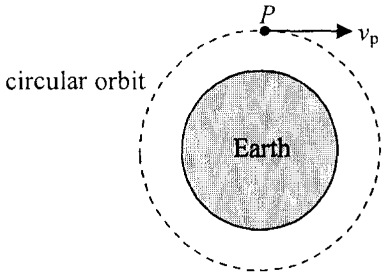
Section A : Astronomy and Space Science

Q.1: Multiple-choice questions

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

$$v_1 < v_P < v_2$$

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



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

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

A ○ B ○ C ○ D ○

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

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

B. 4

C. $\frac{1}{16\sqrt{2}}$

D. $16\sqrt{2}$

A ○ B ○ C ○ D ○

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

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

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

A ○ B ○ C ○ D ○

Please stick the barcode label here.

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

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

A B C D
○ ○ ○ ○

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

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

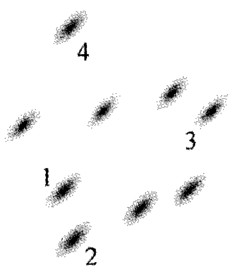
B. $\frac{1}{2}$

C. 2

D. 4

A B C D
○ ○ ○ ○

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



Which of the following statements is/are correct ?

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

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

A B C D
○ ○ ○ ○

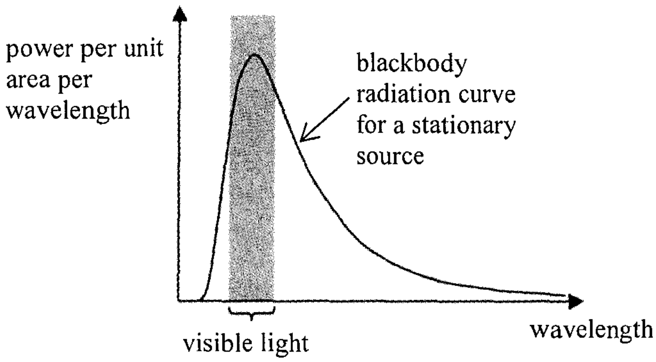
1.7 What information of a star can be deduced from its absorption spectrum ?

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

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

A B C D

1.8



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

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

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

A B C D

Please stick the barcode label here.

Q.1: Structured question

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

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

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

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

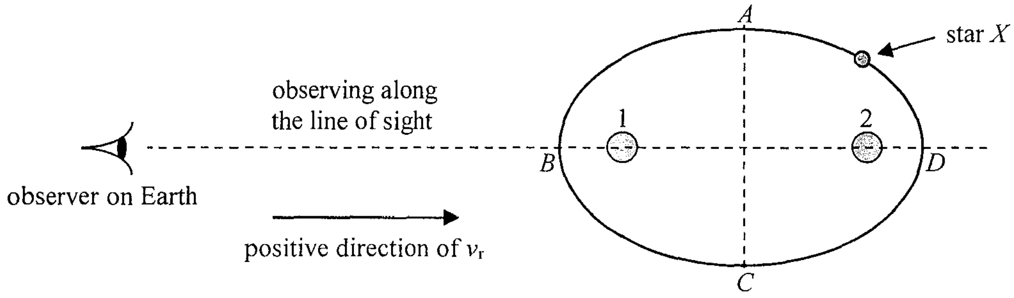
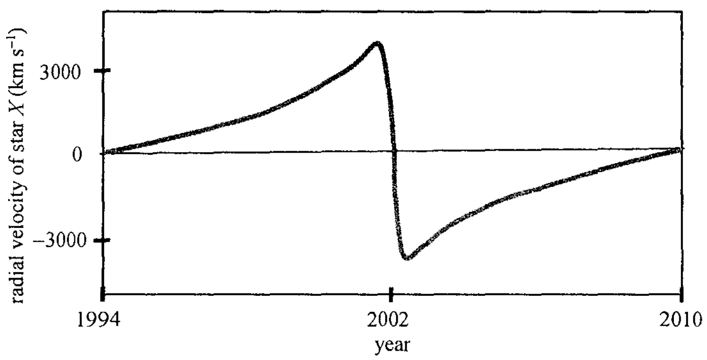


Figure 1.1



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

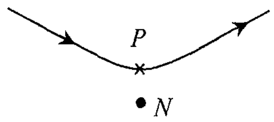
(ii) State where star X is located, A, B, C or D, around the year 2002. Hence determine the location of Sgr A* (position 1 or position 2). Explain your choice. (2 marks)

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

Section B : Atomic World

Q.2: Multiple-choice questions

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

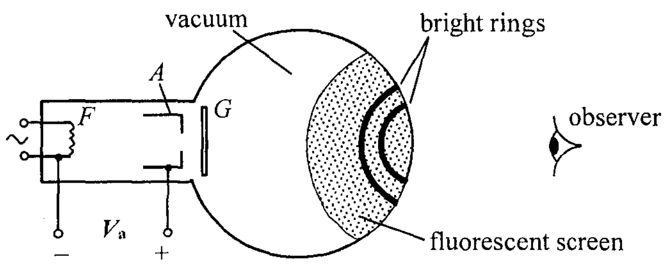


Which statement below is correct ?

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

A B C D
○ ○ ○ ○

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



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

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

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

A B C D
○ ○ ○ ○

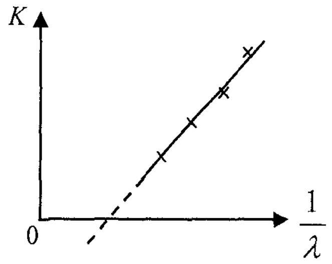
2.3 When monochromatic lights of wavelengths λ and 2λ are incident on a metal surface, the maximum kinetic energies of the photoelectrons emitted are in the ratio of 3:1. Find the longest wavelength of monochromatic light that can trigger photoemission for such metal.

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

A B C D
○ ○ ○ ○

Please stick the barcode label here.

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



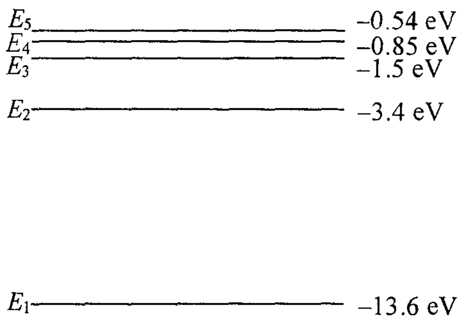
How would the graph change if incident light of lower intensity is shone on another metal having a smaller work function ?

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

A B C D

○ ○ ○ ○

2.5



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

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

A B C D

○ ○ ○ ○

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

A. $\frac{0.04}{\sqrt{V}}$.

B. $\frac{0.12}{\sqrt{V}}$.

C. $\frac{0.4}{\sqrt{V}}$.

D. $\frac{1.2}{\sqrt{V}}$.

A B C D

○ ○ ○ ○

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

(1) The higher resolving power of TEM is enabled by the much shorter wavelength of its electron beam than that of visible light employed in an optical microscope.

(2) The current-carrying coils in a TEM provide magnetic fields for converging the electron beam, which is similar to the lenses in an optical microscope for converging light.

(3) The angular resolution of both microscopes are limited by the Rayleigh's criterion.

A. (1) and (2) only

B. (1) and (3) only

C. (2) and (3) only

D. (1), (2) and (3)

A B C D

○ ○ ○ ○

2.8 A nano material

(1) has a higher volume to surface area ratio than the same substance in bulk form.

(2) has at least one dimension less than 1 nm.

(3) is chemically more reactive than the same substance in bulk form.

A. (1) only

B. (3) only

C. (1) and (2) only

D. (2) and (3) only

A B C D

○ ○ ○ ○

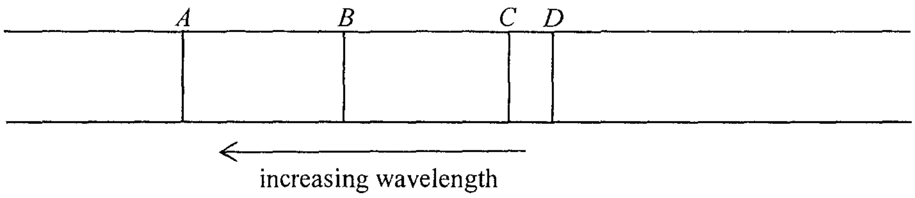
Please stick the barcode label here.

Q.2: Structured question

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

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

Figure 2.1



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

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

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

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

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

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

Section C : Energy and Use of Energy

Q.3: Multiple-choice questions

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

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

A B C D
○ ○ ○ ○

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

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

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

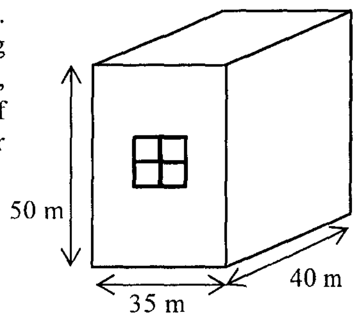
A B C D
○ ○ ○ ○

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

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

A B C D
○ ○ ○ ○

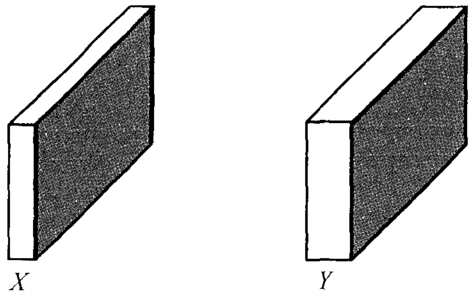
3.4 The figure shows a concrete building of dimensions 35 m × 40 m × 50 m. It is given that the Overall Thermal Transfer Value (OTTV) of a building should not exceed 24 W m^{-2}. Find the maximum number of windows, each of size 2 m × 3 m, that can be installed on the walls of the building if the equivalent temperature difference between the interior and the exterior of the building is 10 °C.
Given: U-value of the concrete of the building = 2.0 W m^{-2} K^{-1}
U-value of the glass of the windows = 5.7 W m^{-2} K^{-1}



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

A B C D
○ ○ ○ ○

3.5



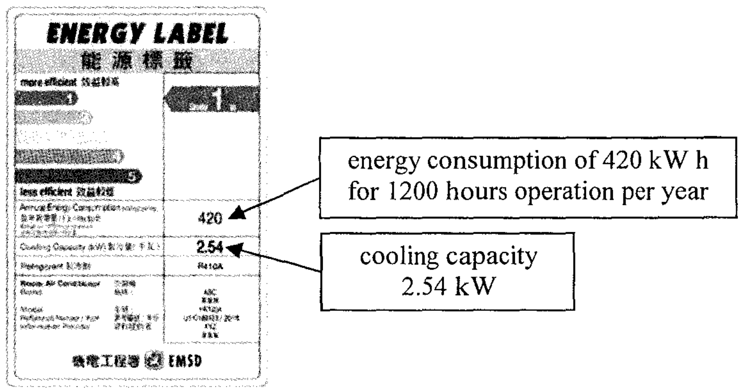
Walls X and Y having the same area are made of the same material, with Y thicker than X. If the temperature difference between the two faces of each wall is the same, X and Y have the same

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

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

A B C D
○ ○ ○ ○

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

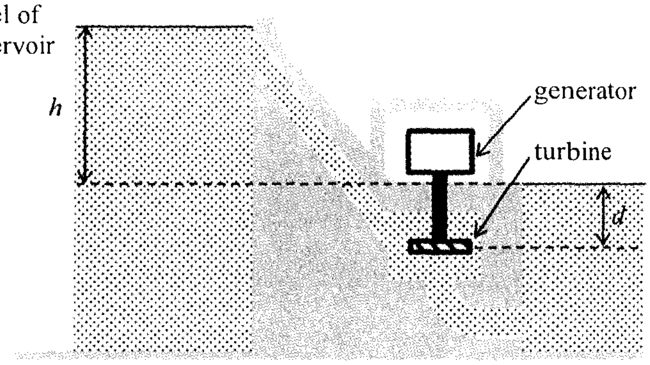


Find the COP (coefficient of performance) of this air-conditioner.

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

A B C D
○ ○ ○ ○

3.7 The figure below shows a hydroelectric power plant.



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

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

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

A B C D

○ ○ ○ ○

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

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

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

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

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

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

D. $\frac{1000}{235} \times 6.02 \times 10^{23} \times 1.49 \times 10^{-10}$

A B C D

○ ○ ○ ○

Q.3: Structured question

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

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

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

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

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

The table below shows more information about the electric vehicles:

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

(c) Referring to all the information given, estimate

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

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

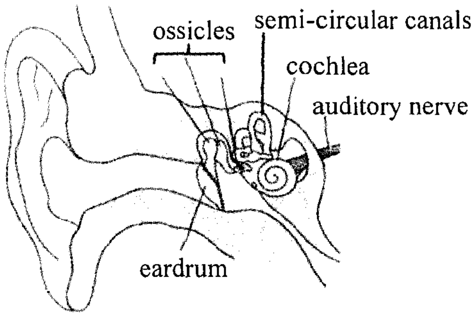
(d) Discuss in which of the driving modes below the regenerative braking system has the highest effectiveness: (2 marks)

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

Section D : Medical Physics

Q.4: Multiple-choice questions

4.1 Which part of the ear discerns frequency ?



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

A B C D

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

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

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

A B C D

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

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

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

A B C D

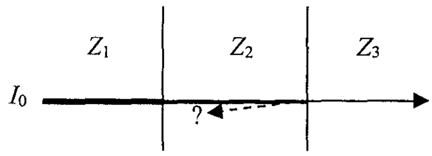
4.4 When diagnosing brain injuries, doctors use computed tomography (CT) scans to locate positions of internal bleeding. With reference to this context, which reasons given below for **NOT** using the respective imaging methods are correct ?

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

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

A B C D
○ ○ ○ ○

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



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

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

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

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

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

A B C D
○ ○ ○ ○

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

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

A B C D
○ ○ ○ ○

4.7 Radionuclide imaging uses only γ radiations as

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

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

A B C D
○ ○ ○ ○

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

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

α is given a much larger radiation weighting factor because it

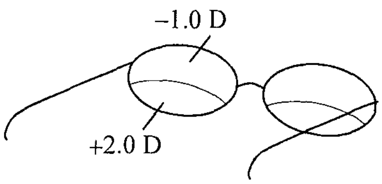
A. has a low penetrating power.
B. has a strong ionizing power.
C. has a relatively larger mass since it is a helium nucleus.
D. is particle in nature.

A B C D
○ ○ ○ ○

Q.4: Structured question

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

Figure 4.1

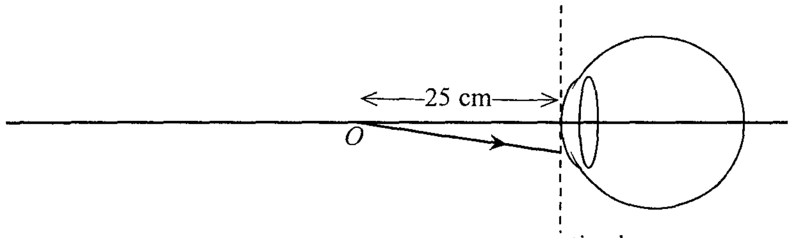


With the spectacles, Roger's near point can be corrected to 25 cm from his eyes while his far point is corrected to infinity. Assume that the lenses are very close to his eyes.

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

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

Figure 4.2

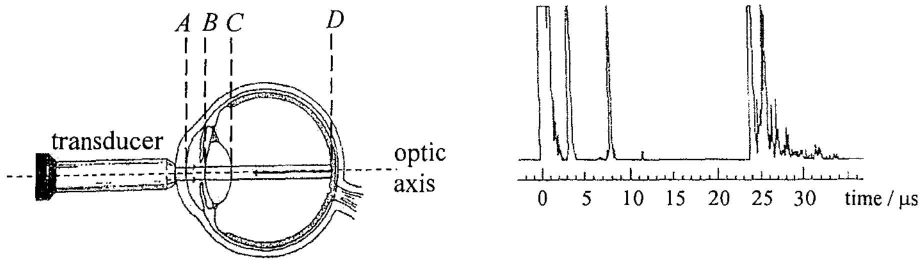


(1) **Copy Figure 4.2 to your answer book** and complete the path of the ray from O to show how it reaches the retina. Indicate the near point N of Roger's unaided eyes in your diagram. Assume that refraction in the eye is due to the eye lens only. (2 marks)

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

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

Figure 4.3



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

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

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

END OF PAPER

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

List of data, formulae and relationships

Data

molar gas constant	$R = 8.31\ \text{J mol}^{-1}\ \text{K}^{-1}$
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		**Energy and Use of Energy**	
$U = -\frac{GMm}{r}$	gravitational potential energy	$E = \frac{\Phi}{A}$	illuminance
$P = \sigma AT^4$	Stefan's law	$\frac{Q}{t} = \kappa\frac{A(T_H - T_C)}{d}$	rate of energy transfer by conduction
$\left\lvert\frac{\Delta f}{f_0}\right\rvert \approx \frac{v}{c} \approx \left\lvert\frac{\Delta\lambda}{\lambda_0}\right\rvert$	Doppler effect	$U = \frac{\kappa}{d}$	thermal transmittance U-value
		$P = \frac{1}{2}\rho Av^3$	maximum power by wind turbine
Atomic World		**Medical Physics**	
$\frac{1}{2}m_e {v_{max}}^2 = hf - \phi$	Einstein's photoelectric equation	$\theta \approx \frac{1.22\lambda}{d}$	Rayleigh criterion (resolving power)
$E_n = -\frac{1}{n^2}\left\{\frac{m_e q_e^4}{8h^2\varepsilon_0^2}\right\} = -\frac{13.6}{n^2}\ \text{eV}$	energy level equation for hydrogen atom	power $= \frac{1}{f}$	power of a lens
		$L = 10\log\frac{I}{I_0}$	intensity level (dB)
$\lambda = \frac{h}{p} = \frac{h}{mv}$	de Broglie formula	$Z = \rho c$	acoustic impedance
		$\alpha = \frac{I_r}{I_0} = \frac{(Z_2 - Z_1)^2}{(Z_2 + Z_1)^2}$	intensity reflection coefficient
$\theta \approx \frac{1.22\lambda}{d}$	Rayleigh criterion (resolving power)	$I = I_0 e^{-\mu x}$	transmitted intensity through a medium

A1.	$E = mc\,\Delta T$	energy transfer during heating and cooling	D1.	$F = \dfrac{Q_1 Q_2}{4\pi\varepsilon_0 r^2}$	Coulomb's law
A2.	$E = l\,\Delta m$	energy transfer during change of state	D2.	$E = \dfrac{Q}{4\pi\varepsilon_0 r^2}$	electric field strength due to a point charge
A3.	$pV = nRT$	equation of state for an ideal gas	D3.	$E = \dfrac{V}{d}$	electric field between parallel plates (numerically)
A4.	$pV = \dfrac{1}{3}Nm\overline{c^2}$	kinetic theory equation	D4.	$R = \dfrac{\rho l}{A}$	resistance and resistivity
A5.	$E_K = \dfrac{3RT}{2N_A}$	molecular kinetic energy	D5.	$R = R_1 + R_2$	resistors in series
			D6.	$\dfrac{1}{R} = \dfrac{1}{R_1} + \dfrac{1}{R_2}$	resistors in parallel
B1.	$F = m\dfrac{\Delta v}{\Delta t} = \dfrac{\Delta p}{\Delta t}$	force	D7.	$P = IV = I^2R$	power in a circuit
B2.	moment = $F \times d$	moment of a force	D8.	$F = BQv\sin\theta$	force on a moving charge in a magnetic field
B3.	$E_P = mgh$	gravitational potential energy	D9.	$F = BIl\sin\theta$	force on a current-carrying conductor in a magnetic field
B4.	$E_K = \dfrac{1}{2}mv^2$	kinetic energy	D10.	$B = \dfrac{\mu_0 I}{2\pi r}$	magnetic field due to a long straight wire
B5.	$P = Fv$	mechanical power	D11.	$B = \dfrac{\mu_0 NI}{l}$	magnetic field inside a long solenoid
B6.	$a = \dfrac{v^2}{r} = \omega^2 r$	centripetal acceleration	D12.	$\varepsilon = N\dfrac{\Delta\Phi}{\Delta t}$	induced e.m.f.
B7.	$F = \dfrac{Gm_1 m_2}{r^2}$	Newton's law of gravitation	D13.	$\dfrac{V_s}{V_p} \approx \dfrac{N_s}{N_p}$	ratio of secondary voltage to primary voltage in a transformer
C1.	$\Delta y = \dfrac{\lambda D}{a}$	fringe separation in double-slit interference	E1.	$N = N_0 e^{-kt}$	law of radioactive decay
C2.	$d\sin\theta = n\lambda$	diffraction grating equation	E2.	$t_{\frac{1}{2}} = \dfrac{\ln 2}{k}$	half-life and decay constant
C3.	$\dfrac{1}{u} + \dfrac{1}{v} = \dfrac{1}{f}$	equation for a single lens	E3.	$A = kN$	activity and the number of undecayed nuclei
			E4.	$\Delta E = \Delta mc^2$	mass-energy relationship