2019-DSE
PHY
PAPER 2

Please stick the barcode label here.

Candidate Number									

HONG KONG EXAMINATIONS AND ASSESSMENT AUTHORITY
HONG KONG DIPLOMA OF SECONDARY EDUCATION EXAMINATION 2019

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 and 7.

(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

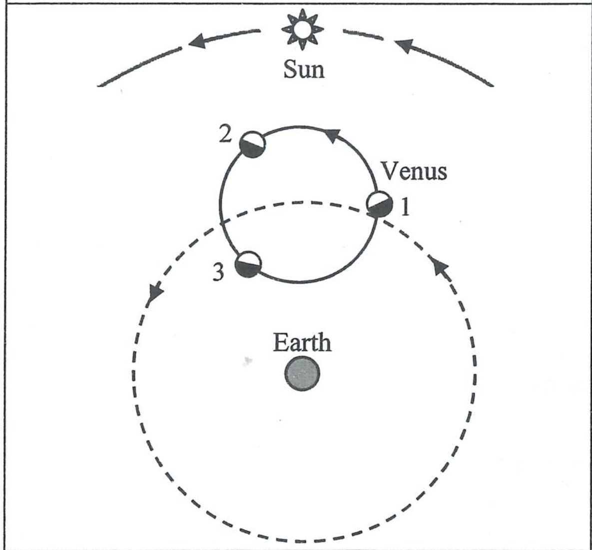
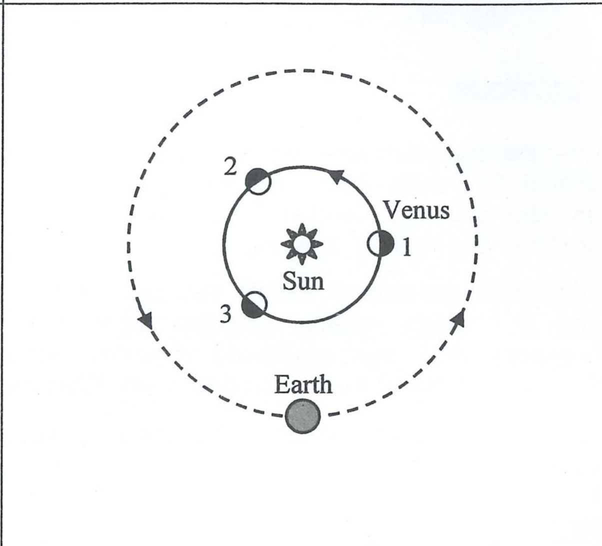
Q.1: Multiple-choice questions

1.1 The size of atomic nucleus is of the order of 10^{-14} m. The size of cluster of galaxies is of the order of 10^{6} pc. The volume ratio of an atomic nucleus to a cluster of galaxies is about ________ .

A. 10^{-37}
B. 10^{-60}
C. 10^{-74}
D. 10^{-111}

A B C D

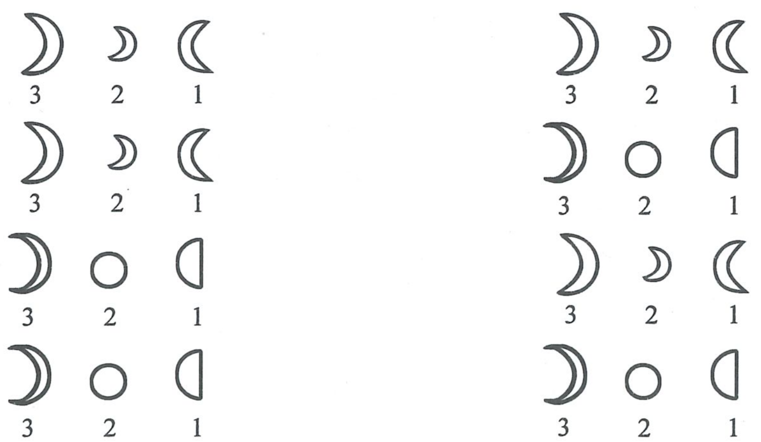
1.2 In the two models below, the numbers indicate three consecutive positions of Venus.

Geocentric model for planetary motion	**Heliocentric model** for planetary motion
	

Which of the following is the prediction of the phases of Venus seen from the Earth according to these two models ?

Geocentric model **Heliocentric model**

A.
B.
C.
D.



A B C D

Please stick the barcode label here.

1.3 Rigel is a star 260 pc from the Sun. What is the shift in angle on photographs of Rigel taken six months apart ?

A. 0.0038″
B. 0.0077″
C. 130″
D. 260″

A B C D

1.4 The luminosity of star X is 256 times that of the Sun and the surface temperature of star X is 2 times that of the Sun. The radius of star X is

A. 4 times that of the Sun.
B. 8 times that of the Sun.
C. 16 times that of the Sun.
D. 64 times that of the Sun.

A B C D

1.5 The hydrogen β line (H_β, $\lambda = 486.1$ nm) of a star observed from the Earth is 486.6 nm. What is the velocity of the star relative to the Earth ?

A. 308.3 km s^{-1} towards the Earth
B. 308.3 km s^{-1} away from the Earth
C. 308.6 km s^{-1} towards the Earth
D. 308.6 km s^{-1} away from the Earth

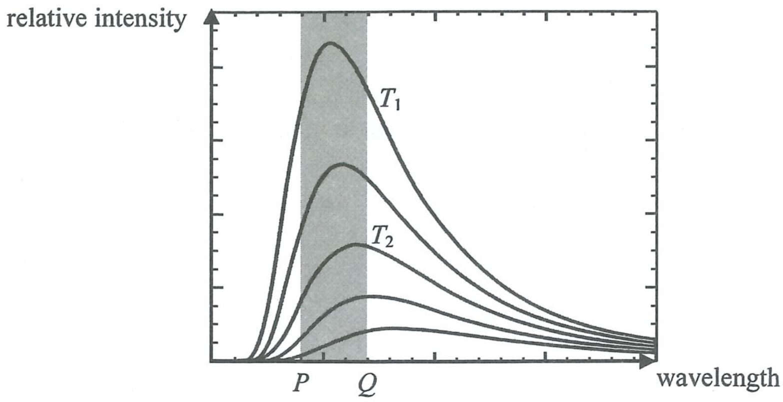
A B C D

1.6 The arrangement of spectral classes of stars in order of increasing surface temperature is

A. KGFAO.
B. OKGFA.
C. AFGKO.
D. OAFGK.

A B C D

1.7 The figure below shows the radiation curves from different stars.



P and *Q* denote the lower and upper wavelength limits of the visible spectrum respectively. T_1 and T_2 are temperatures of the respective radiation curves with one of them belonging to the Sun. Which of the following is correct ?

A. *P* = red; *Q* = violet; T_1 is the Sun's temperature
B. *P* = red; *Q* = violet; T_2 is the Sun's temperature
C. *P* = violet; *Q* = red; T_1 is the Sun's temperature
D. *P* = violet; *Q* = red; T_2 is the Sun's temperature

A B C D
○ ○ ○ ○

1.8 What can we infer about the location of dark matter from the rotation curve of galaxies in the figure below ?

A. Dark matter is mainly distributed near the galactic centre.
B. Dark matter is distributed uniformly throughout the galaxy.
C. Dark matter is distributed more at a large distance from the galactic centre.
D. The rotation curve suggests dark matter exists but does not give us information about its distribution.

A B C D
○ ○ ○ ○

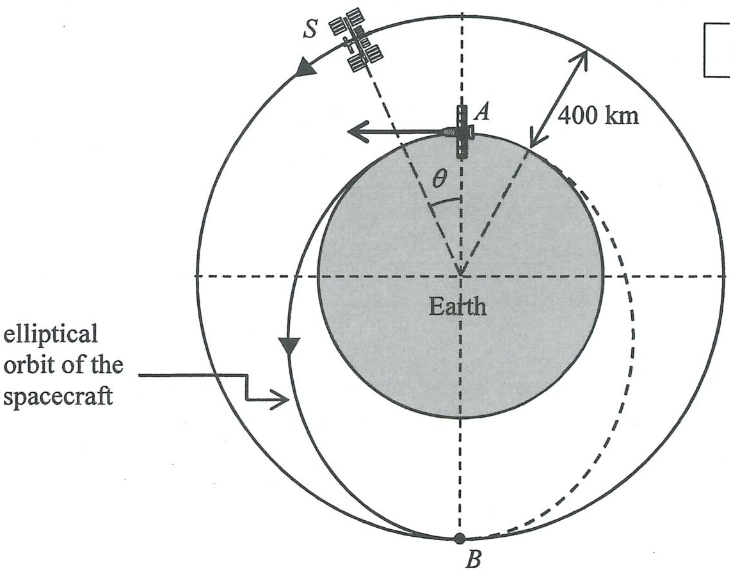
Please stick the barcode label here.

Q.1: Structured question

Figure 1.1 shows a space station S revolving in a circular orbit at a height of 400 km **above** the Earth's surface.

Diagram **NOT** drawn to scale

Figure 1.1



A spacecraft is launched with speed 8.02 km s^{-1} from A at the Earth's surface to meet the station S through an elliptical orbit with AB as the major axis. The spacecraft's rocket engine is shut when it coasts from A to B along the elliptical orbit. Assume that the two orbits are in the same plane.

Given: $GM = 4 \times 10^5$ km^3 s^{-2}, where G is the universal gravitational constant and M is the mass of the Earth.
Radius of the Earth = 6400 km

(a) (i) Using conservation of total mechanical energy, or otherwise, find the speed v_B of the spacecraft when it reaches B. Neglect the effects of the atmosphere. (2 marks)

(ii) Show that the spacecraft takes about 2663 s to travel from A to B. (2 marks)

(iii) Explain why an astronaut in the orbiting spacecraft would experience 'weightlessness'. (1 mark)

(b) The space station S travels at a constant speed of 7.67 km s^{-1} in the circular orbit with a period of 5570 s.

(i) If the spacecraft is to meet the station S exactly when it reaches B, use the result in (a)(ii) to show that their angular separation θ (shown in Figure 1.1) when the spacecraft has just launched at A should be slighty less than 8°. (2 marks)

(ii) In order to make the spacecraft's speed v_B found in (a)(i) exactly the same as that of the station S when they meet at B, a student suggests to slightly adjust the launching speed of the spacecraft at A. Comment on the feasibility of the suggestion. (2 marks)

(iii) Suggest one simple way for the spacecraft at B to travel with the same speed as station S. (1 mark)

Section B : Atomic World

Q.2: Multiple-choice questions

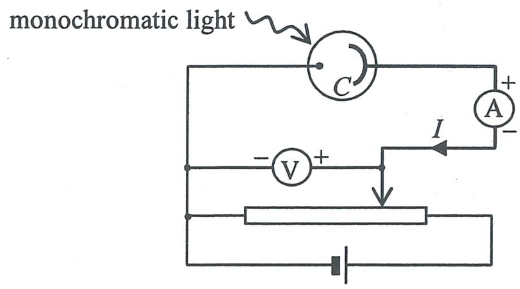
2.1 There are dark lines in the Sun's spectrum because lights at certain wavelengths emitted by the Sun are .

A. completely absorbed by the Sun's atmosphere.
B. completely absorbed by the Earth's atmosphere.
C. partly absorbed by the Sun's atmosphere.
D. partly absorbed by the Earth's atmosphere.

A B C D

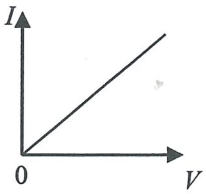
○ ○ ○ ○

2.2 The set-up below is for investigating the maximum kinetic energy of photoelectrons in photoelectric effect.

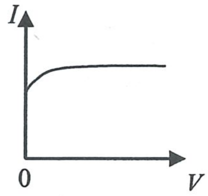


Monochromatic light of fixed intensity is shone on the cathode C of a photocell. The p.d. V applied across the photocell is adjusted and the corresponding current I is measured. What will be the graph of I against V ?

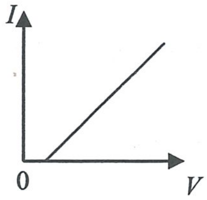
A.



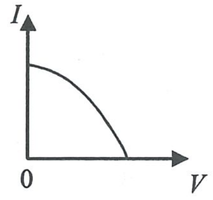
B.



C.



D.



A B C D

○ ○ ○ ○

2.3 What is the maximum kinetic energy of the photoelectrons emitted if gold is illuminated by electromagnetic radiation of wavelength 200 nm ? The work function of gold is 5.30 eV.

A. 0.916 eV
B. 5.30 eV
C. 6.22 eV
D. 11.3 eV

A B C D

○ ○ ○ ○

2.4 Which microscope(s) below can be used to manipulate individual atoms on conductive surfaces ?

(1) optical microscope
(2) scanning tunneling microscope
(3) transmission electron microscope

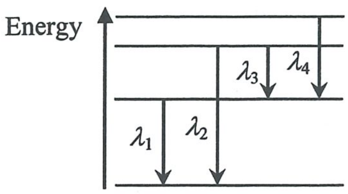
A. (1) only
B. (2) only
C. (1) and (3) only
D. (2) and (3) only

A B C D

○ ○ ○ ○

Please stick the barcode label here.

2.5 The energy diagram for an atom is shown below.



The electron transitions shown give rise to emission lines of wavelengths λ_1, λ_2, λ_3 and λ_4 respectively. Which of the following is/are correct ?

(1) $\frac{1}{\lambda_3} < \frac{1}{\lambda_4}$

(2) $\lambda_1 < \lambda_2$

(3) $\lambda_1 + \lambda_3 = \lambda_2$

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

A B C D

2.6 The de Broglie wavelength of a neutron with kinetic energy 1 keV is λ. If the kinetic energy of the neutron becomes 2 keV, what is its de Broglie wavelength ?

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

A B C D

2.7 Two point sources of red light at a distance of 160 m from an observer can just be resolved by the naked eyes. If they are replaced by point sources of violet light, how should the observer move from the original position such that the two sources can just be resolved ?

A. move about 280 m further away from the sources
B. move about 120 m further away from the sources
C. move about 120 m towards the sources
D. move about 70 m towards the sources

A B C D

2.8 A metal is broken up into nano-sized particles which are then closely packed. Which of the following statements is/are correct ?

(1) The total volume remains more or less unchanged but the total surface area increases.
(2) The shape changes but the arrangement of atoms remains unchanged.
(3) The chemical properties change but the physical properties remain unchanged.

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

A B C D

Go on to the next page

Q.2: Structured question

(a) In Thomson's 'plum-pudding' model of atoms, an atom consists of a lump of positive material embedded with negatively-charged electrons distributed throughout.

(i) In order to test this atomic model, an experiment was performed such that a beam of α particles was shot at a gold foil and the deflections of the α particles were measured. State the result(s) of this scattering experiment. (2 marks)

(ii) Thomson's atomic model cannot account for the results of the scattering experiment in (a)(i). Why ? (1 mark)

(b) The diagram below represents some energy levels of a hydrogen atom. The ground state energy E_0 of hydrogen atom is −13.6 eV.

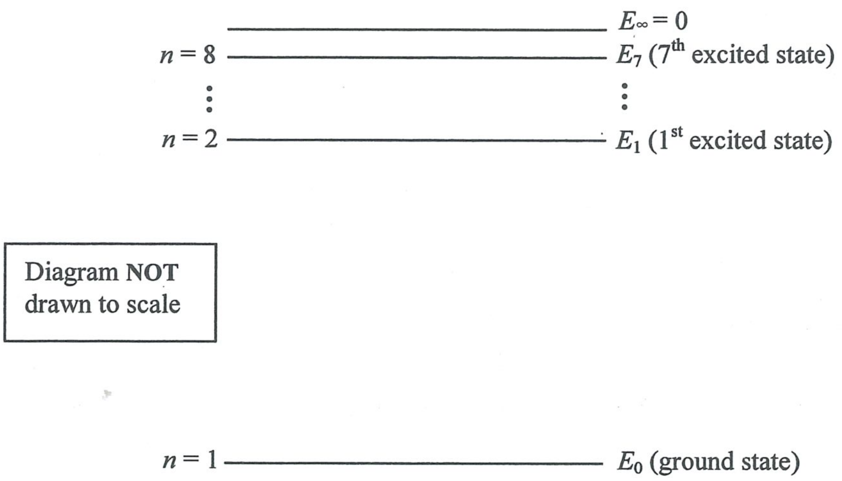


Figure 2.1

(i) All energy levels of a hydrogen atom take negative values except E_∞. State the physical significance of energy levels having 'negative values' and the implication of an electron being at E_∞. (2 marks)

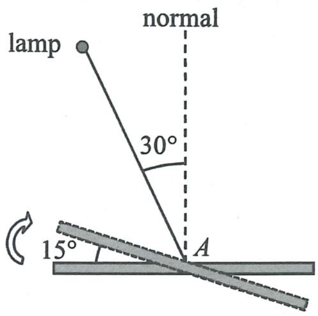
(ii) What is the wavelength of electromagnetic wave emitted from a hydrogen atom which undergoes a transition from its 7th excited state ($n = 8$) to the 1st excited state ($n = 2$). (3 marks)

(iii) Find the minimum energy required to ionize a hydrogen atom from its 3rd excited state (not shown). (2 marks)

Section C : Energy and Use of Energy

Q.3: Multiple-choice questions

3.1 A book in a horizontal position is underneath a lamp positioned at an angle of 30° with the normal to the book as shown. The illuminance on the book around point A is 10 lx. Estimate the illuminance around A when the book is tilted about A by 15°.



A. 5.44 lx
B. 8.16 lx
C. 9.66 lx
D. 12.2 lx

A B C D
○ ○ ○ ○

3.2 The battery pack of an electric vehicle can store 25 kW h of energy when fully charged. The output mechanical power of the vehicle is 12.5 kW and its end-use energy efficiency is 80%. Estimate the maximum duration of travel of the vehicle at this output power.

A. 1.3 hours
B. 1.6 hours
C. 2 hours
D. 2.5 hours

A B C D
○ ○ ○ ○

3.3 Which of the following descriptions about a hybrid car is/are correct ?

(1) The motor and the combustion engine of a hybrid car can be turned on at the same time to drive the car.
(2) A hybrid car is said to be environmental friendly as it does not emit pollutants directly.
(3) If the battery of a hybrid car cannot be charged via a wall socket, it can only be charged through the regenerative braking system during deceleration.

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

A B C D
○ ○ ○ ○

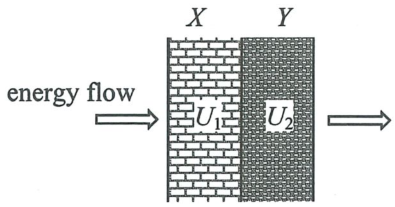
3.4 Air-conditioners P and Q below are used respectively for cooling two identical rooms under the same environmental conditions. Which statement is **INCORRECT** ?

air-conditioner	cooling capacity / kW	coefficient of performance (COP)
P	3.2	2.2
Q	3.0	1.9

A. The room with air-conditioner P cools down quicker.
B. P is more energy efficient.
C. The rate of releasing total amount of thermal energy to the outside is larger for P.
D. P consumes more power.

A B C D
○ ○ ○ ○

3.5



A wall is composed of layers X and Y of U-values U_1 and U_2 respectively. Both layers have the same thickness and dimensions, and there is no air gap between them. Which expression gives the U-value of the wall ?

A. $U_1 + U_2$

B. $\frac{1}{2}(U_1 + U_2)$

C. $\frac{2U_1U_2}{U_1 + U_2}$

D. $\frac{U_1U_2}{U_1 + U_2}$

A B C D

○ ○ ○ ○

3.6 Which of the following arrangements can reduce the Overall Thermal Transfer Value (OTTV) of a building ?

(1) adding heat insulating materials onto the building envelope
(2) introducing air space in walls
(3) replacing concrete walls with glass windows

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

A B C D

○ ○ ○ ○

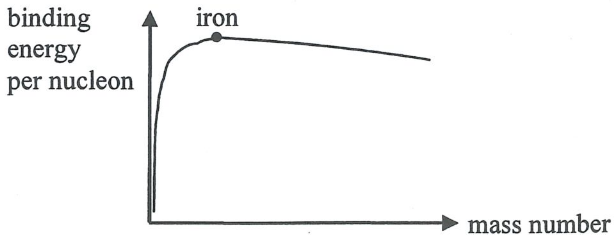
3.7 A wind turbine delivers a power of 800 W at a wind speed of 4 m s^{-1} blowing normal to its blades. Estimate the power delivered by the turbine if the wind speed increases to 6 m s^{-1} blowing in the same direction.

A. 1200 W
B. 1800 W
C. 2700 W
D. 3200 W

A B C D

○ ○ ○ ○

3.8



Which of the following can be directly inferred from the above binding energy curve ?

(1) The negative slope of the curve indicates that the total mass of the nuclides produced after fission is larger than the mass of the heavy nucleus before fission.
(2) The positive steep slope of the curve characterises that nuclear fusion in general produces much more energy per nucleon than nuclear fission.
(3) Iron being at the peak of the curve indicates that this element has the most stable atomic nucleus.

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

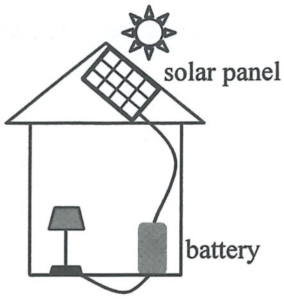
(a) The total power of the Sun is about 3.86×10^{26} W, which radiates evenly in all directions. The Earth is at a mean distance of 1.50×10^{11} m from the Sun.

(i) Estimate the solar radiation power per unit area that can be obtained at the same distance of the Earth from the Sun. (2 marks)

(ii) State a reason why the maximum solar radiation power per unit area received on the Earth's surface normal to the Sun is only around 70% of that found in (a)(i). (1 mark)

(b) In the domestic energy storage system shown in the simplified schematic diagram below, energy from the Sun reaching a solar panel can be stored in a battery.

Figure 3.1



The solar panel of area 1.65 m^2 is connected to the battery via a charger controller (not shown in Figure 3.1). The solar panel delivers 300 W when it is normal to the Sun on a sunny day. Given: solar radiation power per unit area received on the Earth's surface = 1000 W m^{-2}

(i) Describe the energy conversions during charging in this domestic energy storage system. (2 marks)

(ii) Find the efficiency of the solar panel. (2 marks)

(iii) The capacity of the storage battery is '100 Ah 12 V'. How long would it take for the solar panel to fully charge the battery, which is completely discharged initially, if 20% energy loss occurs during charging ? State one assumption in your calculation. (3 marks)

Section D : Medical Physics

Q.4: Multiple-choice questions

4.1 John suffers from long-sightedness. After wearing suitable corrective spectacles, how would his near-point distance and far-point distance be affected ?

	near-point distance	far-point distance
A.	increased	increased
B.	increased	unchanged
C.	decreased	decreased
D.	decreased	unchanged

A B C D

○ ○ ○ ○

4.2 An object is placed 20 cm in front of a concave lens. The magnification of the image is 0.5. Find the power of the lens.

A. +20 D
B. –5 D
C. –10 D
D. –20 D

A B C D

○ ○ ○ ○

4.3 The maximum sensitivity of human ear to sound of frequency 3 kHz is about 0.5 dB, which is the minimum change in sound intensity level that can be detected by the ear. This corresponds to a change of sound intensity of approximately

A. 12%.
B. 6%.
C. 3%.
D. 1%.

A B C D

○ ○ ○ ○

4.4 Which of the following is/are non-invasive medical imaging method(s) ?

(1) endoscopy
(2) computed tomography (CT) scan
(3) radioactive tracers

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

A B C D

○ ○ ○ ○

4.5 Which statement about radiographic imaging and computed tomography (CT) scan is correct ?

A. Both make use of the different degree of attenuation of the radiation beam through various body tissues.
B. The X-rays used in radiographic imaging are ionizing radiations while CT scans employ non-ionizing radiations.
C. CT scans produce images of relatively higher resolution because gamma radiation is used.
D. CT scans cannot be used for organs with cavity.

A B C D
○ ○ ○ ○

4.6 Which statement about a 'hot spot' and a 'cold spot' in a radionuclide image is correct ?

A. A cold spot indicates the degree of abnormality of a particular organ but a hot spot does not.
B. Both indicate the concentration of artificial contrast medium in a particular organ.
C. Both indicate the concentration of the radioactive tracer in a particular organ.
D. Both indicate the degree of reflection of the radiation by the abnormal part of an organ.

A B C D
○ ○ ○ ○

4.7 The effective half-life of a certain radioactive tracer X is 6.9 hours. If the biological half-life of X is 2 days, find its physical half-life.

A. 2.8 hours
B. 6.0 hours
C. 7.3 hours
D. 8.1 hours

A B C D
○ ○ ○ ○

4.8 A gamma source Y is used externally for treatment of cancer. At a certain point from source Y the equivalent dose rate is 24 μSv per hour. It is found that 242 mm of concrete shielding is needed to reduce the equivalent dose rate to 1.5 μSv per hour at the same point. The half-value thickness of concrete for gamma radiation is

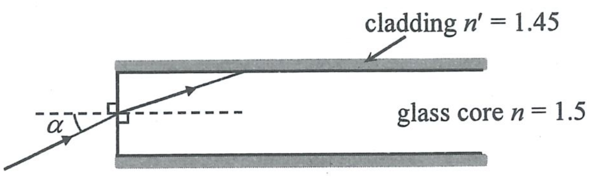
A. 48.4 mm.
B. 60.5 mm.
C. 80.6 mm.
D. 121.0 mm.

A B C D
○ ○ ○ ○

Q.4: Structured question

(a) An endoscope is made of a bundle of optical fibres with each optical fibre having a glass core surrounded with a cladding as shown in Figure 4.1. The endoscope can be inserted through natural openings of a patient in order to view internal organs. The refractive index of the glass core and that of the surrounding cladding are 1.5 and 1.45 respectively.

Figure 4.1



(i) Find the critical angle c for the core-cladding boundary. (1 mark)

(ii) Explain why a light ray entering the glass core at an angle α as shown can be guided through the core without leakage only if α is less than a certain angle α_{max}. (2 marks)

(iii) A patient suffers from stomach ulcer (i.e. a wound on the stomach lining). State **ONE** advantage and **ONE** disadvantage of examining the stomach using endoscopy over radiographic imaging using X-rays. (2 marks)

(b) The table shows information relating to the transmission of sound through different types of body tissues.

Tissue	**Speed of sound / m s^{-1}**	**Acoustic impedance / kg m^{-2} s^{-1}**
Bone	3780	7.15×10^6
Muscle	1590	1.65×10^6
Fat	1450	1.37×10^6

(i) Estimate the density of bone. (1 mark)

(ii) When ultrasound is incident to a 'muscle-bone' boundary, find the ratio of the intensity of ultrasound reflected from the boundary to that incident to the boundary. (2 marks)

(iii) Explain why in an ultrasound scan a 'muscle-bone' boundary is easier to be distinguished compared to a 'muscle-fat' boundary. (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.

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	$e = 1.60 \times 10^{-19}\ \text{C}$	
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
$P = \sigma AT^4$	Stefan's law
$\left\lvert\frac{\Delta f}{f_0}\right\rvert \approx \frac{v}{c} \approx \left\lvert\frac{\Delta\lambda}{\lambda_0}\right\rvert$	Doppler effect

Energy and Use of Energy

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

Atomic World

$\frac{1}{2}m_e {v_{max}}^2 = hf - \phi$	Einstein's photoelectric equation
$E_n = -\frac{1}{n^2}\left\{\frac{m_e e^4}{8h^2\varepsilon_0^2}\right\} = -\frac{13.6}{n^2}\ \text{eV}$	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)
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 width 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