2023-DSE
PHY
PAPER 2

Name	
Class	
Class No.	

Methodist College
F.6 First Examination 2022-23

PHYSICS PAPER 2

Question-Answer Book

27th October, 2022.
11.30 am – 12.30 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 name, class and number on the front page.

(2) There are 16 multiple-choice questions in Part A and 2 structured questions in Part B. Attempt **ALL** questions in both parts.

(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 name, class and number 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.

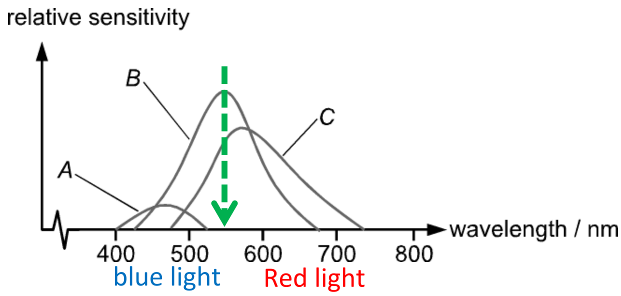
(6) The diagrams in this paper are **NOT** necessarily drawn to scale.

(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.

Part A

1. The graph below shows the receptor absorption curves of the three cones *A*, *B* and *C* in an eye.



Which of the following statements is **incorrect**?

A *B* is more sensitive to red light than *C*.

B All three cones respond to light of 500 nm.

C *B* is the most sensitive to green lights among the cones.

D The eye responds to light of wavelengths ranging from 400 to 700 nm.

A B C D

2. When Victoria focuses on an object 40 cm in front of her eye, the power of her eye is 48 D. What is the lens-to-retina distance of her eye?

A 1.14 cm

B 2.08 cm

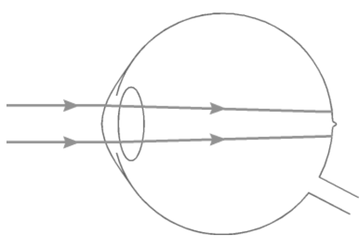
C 2.20 cm

D 2.50 cm

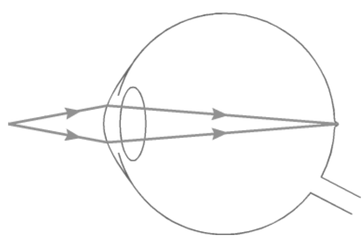
A B C D

3. Which of the following diagrams best shows a long-sighted eye viewing a near object?

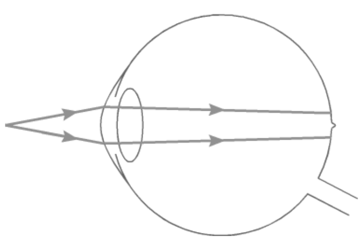
A



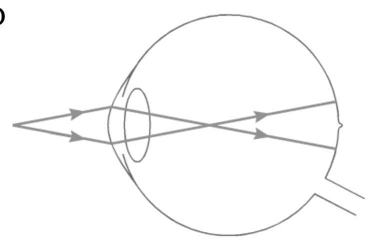
B



C



D



A B C D

4. A short-sighted person, wearing a suitable corrective lens, sees a distant object clearly. When he looks at the distant object,

A an erect image is formed by the lens of the eye and is positioned on the retina.

B an erect image is formed by the corrective lens and is positioned on the retina.

C an erect image is formed by the lens of the eye and is positioned at the far point of the eye.

D an erect image is formed by the corrective lens and is positioned at the far point of the eye.

A B C D

5. The near point of Hinson's eye is at 40 cm. If he wears a corrective lens of power 2 D, which of the following statements is correct?

A He can focus on an object at a minimum distance of 22 cm.
B He can focus on an object at a minimum distance of 20 cm.
C He can focus on an object at a maximum distance of 22 cm.
D He can focus on an object at a maximum distance of 2 m.

A B C D
○ ○ ○ ○

6. In reading the headline on a newspaper, Edwin needs to resolve points on the newspaper that are about 3 mm apart. If the diameter of the pupil of Edwin's eye is 2 mm, what is the maximum distance between his eye and the newspaper? Take the wavelength of light from the newspaper to be 550 nm.

A 8.94 m
B 9.17 m
C 10.9 m
D 11.2 m

A B C D
○ ○ ○ ○

7. The refractive indices of the core and the cladding of an optical fibre are 1.46 and 1.44 respectively. Find the critical angle at the core-cladding interface.

A 9.5°
B 43.6°
C 44.6°
D 80.5°

A B C D
○ ○ ○ ○

8. Which of the following is/are advantage(s) of using an endoscope in diagnosis?

(1) There is no need to make a large surgical cut to look inside the patient.
(2) It does not cause discomfort to the patient.
(3) It does not involve ionizing radiation.

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

A B C D
○ ○ ○ ○

9. Two coherent fibre bundles P and Q have the same diameter, but P consists of more numerous and finer optical fibres than Q. Which of the following statements is/are correct?

(1) The image formed by P is much brighter than Q.
(2) The resolution of the image formed by P is higher than Q.
(3) P can be bent more than Q.

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

A B C D
○ ○ ○ ○

10. Suppose the sound intensity level is increased from 40 dB to 50 dB. What is the intensity ratio of the initial sound to the final sound?

A 1 : 5
B 1 : 10
C 1 : 20
D 4 : 5

A B C D
○ ○ ○ ○

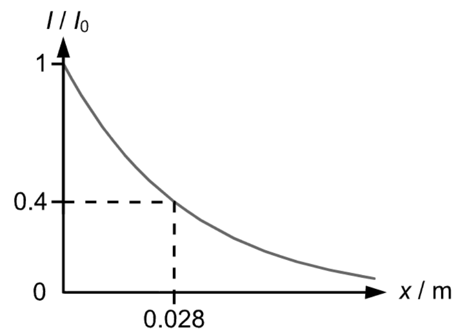
11. An earplug can reduce the sound intensity level heard by 29 dB. What is the ratio of the sound intensity heard to that of the original?

A 1/200
B 1/800
C 1/1600
D 1/3200

12. What does the grey scale of images on an X-ray film represent?

A density of the tissue
B intensity of the X-rays detected
C the linear attenuation coefficient of the X-ray in different tissues
D the intensity of the X-rays reflected from the boundary of the tissue

13. An X-ray beam of intensity I travels through a certain distance x in a muscle. The following graph shows the relation between I and x.



Find the linear attenuation coefficient of the muscle.

A $9\ m^{-1}$
B $33\ m^{-1}$
C $40\ m^{-1}$
D $57\ m^{-1}$

A B C D
○ ○ ○ ○

14. After an X-ray beam passes through a metal of 0.1 m thick, the intensity of the beam is decreased by 36%. What is the half-value thickness of the metal?

A 0.07 m
B 0.11 m
C 0.16 m
D 0.19 m

A B C D
○ ○ ○ ○

15. Which of the following statements about artificial contrast media used in X-ray imaging is incorrect?

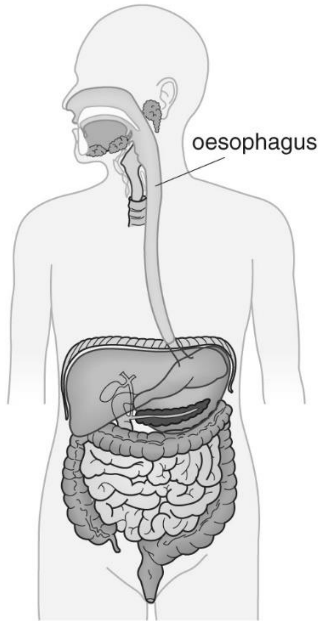
A They can increase the attenuation of X-rays in the target structure.
B Barium is a common type of contrast medium used.
C They are non-radioactive.
D They are always introduced into the body through swallowing. ×

A B C D
○ ○ ○ ○

Common contrast media:

- Barium: (shallowed) used for imaging the stomach, the intestines, etc.
- Iodine: (injected) used for imaging the heart, the blood vessels, etc.

16. A patient is suspected to have an oesophagus tumor (食道腫瘤).



Which of the following medical imaging methods is the most suitable for investigation?

A Ultrasound A-scan

B Ultrasound B-scan

C X-ray radiography

D Fibre optic endoscopy

A	B	C	D
○	○	○	○

End of Part A

Part B

1 **(a)** The acoustic impedance of air is 411 kg m^{-2} s^{-1}, while the acoustic impedance of the fluid inside the inner ear is 1.6×10^6 kg m^{-2} s^{-1}.

(i) It is given that the speed of sound in air is 330 m s^{-1}. Estimate the density of air. (1 mark)

(ii) If the middle ear was not present and a sound of intensity ***I*** was incident directly from the air to the fluid in the inner ear along the normal direction, what percentage of the intensity of the sound would be transmitted into the inner ear? (3 marks)

(iii) Explain the important role of the middle ear in the hearing process. (2 marks)

(b) Fig.1.1 shows the curves of equal loudness of Tom. He hears a soft voice of frequency 200 Hz and is represented by point P in fig.1.1.

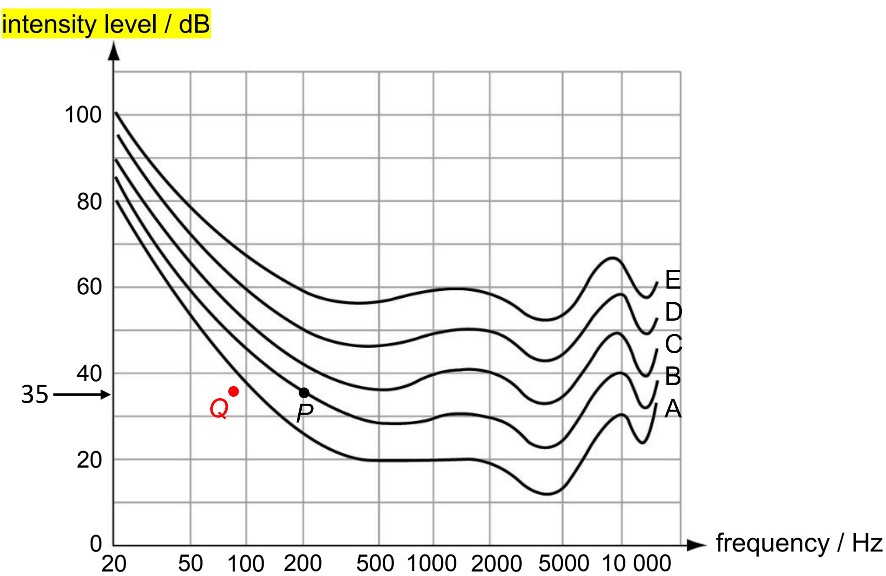


Fig.1.1

(i) State the loudness, in phons, of the voice represented by P. (1 mark)

(ii) What is the intensity of sound represented by P? intensity ≠ intensity level (2 marks)

(iii) A man with deeper voice (frequency around 90 Hz) speaks to Tom with the same intensity as P. Explain why Tom may not clearly hear his sayings. (1 mark)

2. Fig.2.1 shows an ultrasound image of a gallbladder 膽囊 (pointed by the white arrow) which demonstrates the typical appearance of a gallstone 膽石.

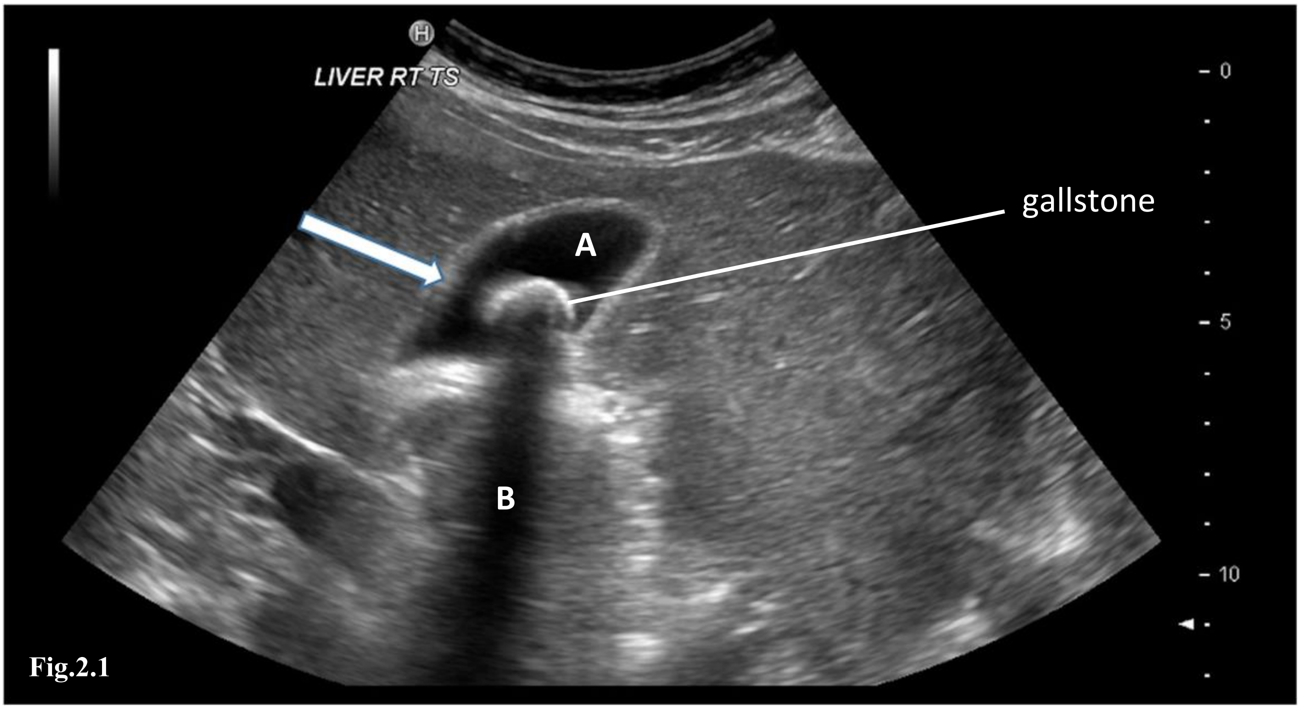


Fig.2.1

(a) (i) Why is the gallstone image's surface particularly bright? (1 mark)

(ii) How do the dark regions A and B form? (2 marks)

(iii) Do you agree that region B cannot be examined by ultrasound scanning? Why? (2 marks)

(b) When carrying the ultrasound scanning, a train of ultrasound pulses is incident perpendicularly through the skin into the body. The table below shows the density ρ and the ultrasound speed c in air and skin.

medium	ρ **/ kg m**$^{-3}$	c **/ m s**$^{-1}$
air	1.18	346
skin	1050	1580

(i) What is the percentage of ultrasound being reflected by the skin? (3 marks)

(ii) What can be done to reduce the reflection by the skin? (1 mark)

(c) Fig.2.2 shows an ultrasound image of a fetus. Explain why X-ray is seldom used to examine fetus. (1 mark)

Fig.2.2

End of Paper

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	$h = 6.63 \times 10^{-34} \text{ J s}^{-1}$

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
$\left\lvert\frac{\Delta f}{f_0}\right\rvert \approx \frac{v}{c} \approx \left\lvert\frac{\Delta\lambda}{\lambda}\right\rvert$	Doppler effect

Energy and Use of Energy

$E = \frac{\Phi}{A}$	illuminance
$\frac{Q}{t} = k\frac{A(T_H - T_C)}{d}$	rate of energy transfer by conduction
$U = \frac{k}{d}$	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
$E_n = -\frac{1}{n^2}\left\{\frac{m_e e^4}{8h^2\epsilon_0^2}\right\} = -\frac{13.6}{n^2}\text{eV}$	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	D1.	$F = \dfrac{Q_1 Q_2}{4\pi\epsilon_0 r^2}$	Coulomb's law
A2.	$E = \ell \Delta m$	energy transfer during change of state	D2.	$E = \dfrac{Q}{4\pi\epsilon_0 r^2}$	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.	$pV = \dfrac{1}{3} N m \overline{c^2}$	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.	$P = IV = I^2 R$	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.	$E_K = \dfrac{1}{2} m v^2$	kinetic energy	D10.	$B = \dfrac{\mu_0 I}{2\pi r}$	magnetic field due to a long straight wire
B5.	$P = Fv = \dfrac{W}{t}$	mechanical power	D11.	$B = \dfrac{\mu_0 N I}{l}$	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.	$F = \dfrac{G m_1 m_2}{r^2}$	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 width in double-slit interference	E1.	$N = N_0 e^{-kt}$	law of radioactive decay
C2.	$d \sin\theta = n\lambda$	diffraction grating equation	E2.	$t_{½} = \dfrac{\ln 2}{k}$	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.	$E = mc^2$	mass–energy relationship