2021-2022
PHY
PAPER 2

Bishop Hall Jubilee School
2021-2022 Mock Examination

F.6 PHYSICS PAPER 2
Question-Answer Book

Date: 23-2-2022
Time: 11:30 – 12:30
Duration: 60 mins
Total page no.: 12 (including cover page)
This paper must be answered in English
Full marks: 36 (18 marks from each section)

Name	
Class	
Class No.	

INSTRUCTIONS

1. There are **TWO** sections, Sections A, and B in this paper. Each section contains eight multiple-choice questions carrying one mark each, and one structured question which carries 10 marks. Attempt **ALL** questions in these **TWO** sections.

2. Write your answers in the spaces provided in this Question-Answer Book. 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.

3. The diagrams in this paper are **NOT** necessarily drawn to scale.

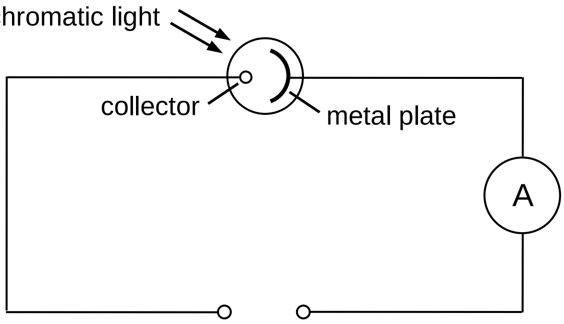
4. The last two pages of this question paper contain a list of data, formulae and relationships which you may find useful.

Q.1	
Q.2	
Total	

Section A: Atomic World

Q.1: Multiple-choice questions

1.1 In the photoelectric experiment below, when monochromatic light is incident on the metal plate, photoelectrons are emitted and a photoelectric current is measured.



Which of the following statements must be correct?

A The kinetic energies of the photoelectrons are larger than the work function of the metal plate.

B The kinetic energies of the photoelectrons are equal to the energy of the incident photons minus the work function of the metal plate.

C The photoelectric current can be stopped by applying a stopping potential.

D Using light of higher frequency and equal intensity can increase the photoelectric current.

A	B	C	D
○	○	○	○

1.2 In the photoelectric effect experiment (Fig a), the metal plate is illuminated with monochromatic light of frequency f. The stopping potential V_s required to stop the photoelectric current for different f is then measured. The result is plotted in Figure b.

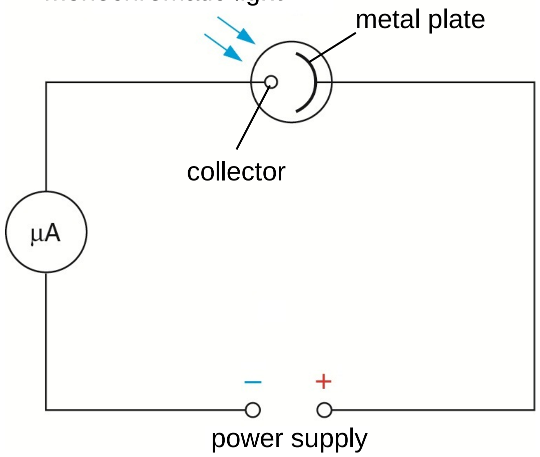


Fig a

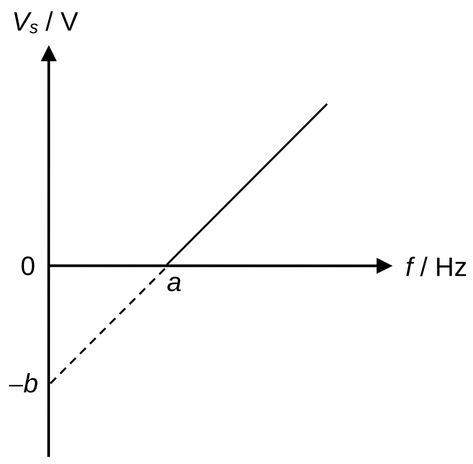


Fig b

Which of the following gives an estimation of Planck constant obtained from the graph (e is the charge of electron)?

A $\frac{b}{e}$

B $\frac{a}{be}$

C $\frac{b}{ae}$

D $\frac{be}{a}$

A B C D

1.3 A metal surface is illuminated by a beam of monochromatic light and emits photoelectrons. When the intensity of the incident light increases while the frequency is kept unchanged,

(1) the number of photoelectrons emitted from the metal surface in each second increases.

(2) the energy of each incident photon increases.

(3) the average kinetic energy of the photoelectrons emitted from the metal surface increases.

A (1) only

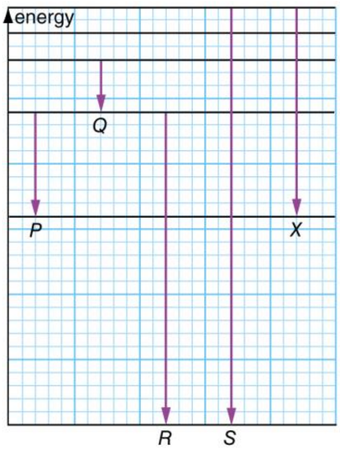
B (2) only

C (1) and (3) only

D (2) and (3) only

A B C D

1.4 The figure below (drawn to scale) shows some energy levels of a certain atom.



Transition X results in the emission of a photon of wavelength λ. Which transition would result in the emission of a photon of wavelength 2λ?

A Transition P

B Transition Q

C Transition R

D Transition S

A B C D

1.5 Particles X and Y have the same mass. The de Broglie wavelength of X is λ while that of Y is 2λ. Which of the following statements is/are correct?

(1) If the momentum of Y is p, the momentum of X is $2p$.

(2) If the kinetic energy of Y is E, the kinetic energy of X is $2E$.

(3) If the speed of Y is v, the speed of X is $2v$.

A (1) only

B (2) only

C (1) and (3) only

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

A ◯ **B** ◯ **C** ◯ **D** ◯

1.6 The transitions of electrons between three energy states in a hydrogen atom result in three spectral lines. The lowest and highest frequencies of these spectral lines are f_1 and f_2 respectively. What is the frequency of the third spectral line?

A $f_2 - f_1$

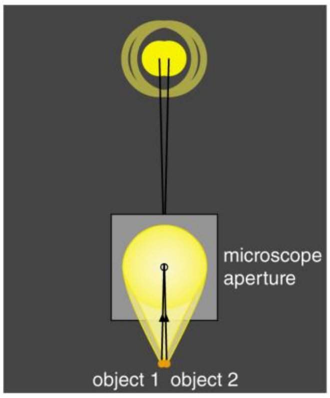
B $\dfrac{f_1 + f_2}{2}$

C $\left(\dfrac{1}{f_1} - \dfrac{1}{f_2}\right)^{-1}$

D $\dfrac{f_1 f_2}{f_1 + f_2}$

A ◯ **B** ◯ **C** ◯ **D** ◯

1.7 In the figure below, the images of the two objects are formed by a microscope. The objects are not resolved.



Which of the following ways can make the two objects become resolved?

(1) Use lights of shorter wavelengths to illuminate the objects.

(2) Increase the distance between the aperture and the objects.

(3) Increase the size of the aperture.

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 A transmission electron microscope (TEM) has an angular resolution of θ (in rad) when the voltage of its electron gun is set at V. Suppose its resolving power is limited by diffraction only. To change the angular resolution of the microscope to $\frac{\theta}{2}$, the voltage of its electron gun should be set to

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

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

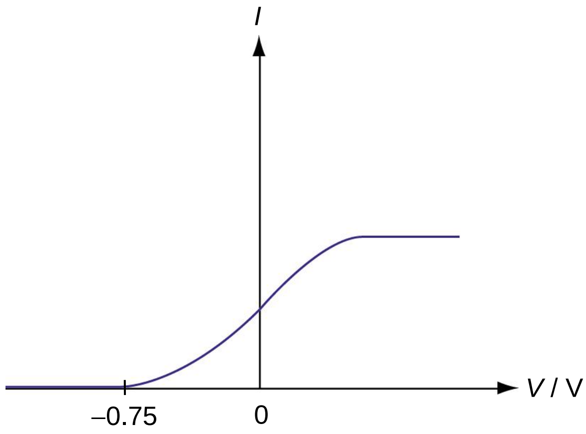
C $2V$.

D $4V$.

A ○ **B** ○ **C** ○ **D** ○

Q.2: Structured question

A photocell is connected to a variable power supply. The metal plate in the photocell is illuminated by violet light of wavelength 400 nm. As the voltage V of the power supply varies, the photoelectric current I changes. A graph of I against V is plotted below.



(a) What is the maximum kinetic energy of the photoelectrons emitted from the metal plate? Express the answer in eV. (1 mark)

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(b) State the meaning of work function. (1 mark)

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(c) Find the work function of the metal plate in the photocell. Express the answer in eV. (3 marks)

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(d) Determine whether the photoelectric effect would occur if green light of wavelength 500 nm is incident on the metal plate. (3 marks)

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(e) If the intensity of the original light source is halved, sketch the corresponding curve on the same graph. (2 marks)

Section B: Energy and Use of Energy

Q.2: Multiple-choice questions

2.1 An air conditioner is used to keep a room cool. Which of the following statements about the condensing coil the air conditioner is/are correct?

(1) It is located outside the room.

(2) It cools down the surrounding air.

(3) The refrigerant condenses when passing through it.

A (2) only

B (1) and (3) only

C (2) and (3) only

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

A B C D

○ ○ ○ ○

2.2 Which of the following statements about a microwave oven is/are correct?

(1) Eddy currents flow in the food when it absorbs the microwaves.

(2) Its major energy loss takes place in the magnetron tube.

(3) There is a significant energy loss due to the leakage of microwaves from the oven.

A (1) only

B (2) only

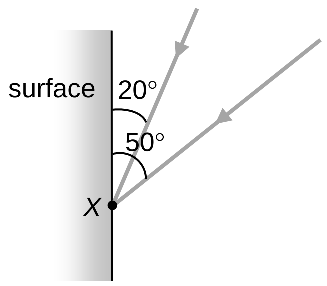
C (1) and (3) only

D (2) and (3) only

A B C D

○ ○ ○ ○

2.3 The figure below shows a flat surface on an artificial satellite. When sunlight makes an angle of 20° to the surface, the illuminance at X is E. What is the illuminance at X when sunlight makes an angle of 50° to the surface?



A $0.45E$

B $0.68E$

C $1.46E$

D $2.24E$

A B C D

○ ○ ○ ○

2.4 Lamp X emits green light while lamp Y emits red light. The two lamps have the same input power and efficacy. Which of the following statements must be correct?

(1) They appear to have the same brightness from the same distance.

(2) Y converts more electrical energy into visible light than X does.

(3) The total output power of Y is larger than that of X.

A (1) only

B (1) and (2) only

C (2) and (3) only

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

A	B	C	D
○	○	○	○

2.5 Under a certain temperature difference, the rate of energy transfer through a wall by conduction is W. If the thickness of the wall is doubled and the area is halved, what is the new rate of energy transfer through the wall by conduction under the same temperature difference?

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

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

C W

D $4W$

A	B	C	D
○	○	○	○

2.6 The fuel efficiency of a fossil-fuel car is 11 km L^{-1}. This means that the car can travel a distance of 11 km by consuming 1 L of petrol. The fuel efficiency of a hybrid car is 16 km L^{-1}. 1 L of petrol costs $15. What is the difference in fuel cost between the two cars in travelling a distance of 50 km?

A $16.7

B $21.3

C $42.6

D $75

A	B	C	D
○	○	○	○

2.7 Wind turbine X with blade length L is blown normally by wind at a speed v and has an output power P. Wind turbine Y has a blade length of $\frac{L}{2}$ and is blown normally by wind at a speed of $2v$. If the wind turbines have the same overall efficiency, what is the output power of wind turbine Y?

A P

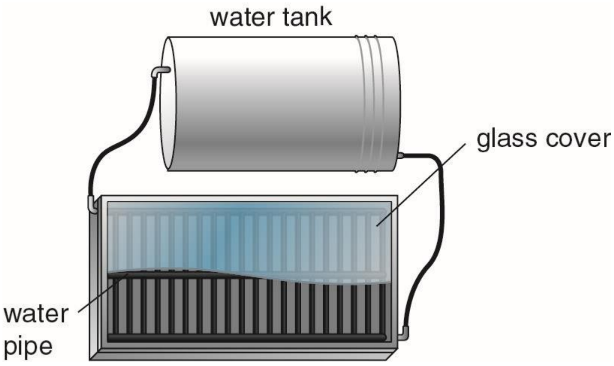
B $2P$

C $4P$

D $8P$

A	B	C	D
○	○	○	○

2.8 A solar water heater is shown below.



Which of the following features of the solar water heater enhance(s) its output power?

(1) The water pipe is painted black.

(2) The heater is placed on the roof.

(3) The water is kept flowing.

A (1) only

B (3) only

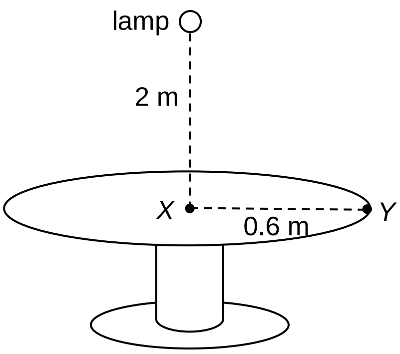
C (2) and (3) only

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

A ◯ B ◯ C ◯ D ◯

Q.2: Structured question

A lamp consisting of 6 CFLs is 2 m above a dining table as shown. Each CFL is rated at '18 W, 1000 lm'. *X* is a point on the table directly under the lamp. Assume that the lamp is a point source and is the only light source in the room.



(a) Find the efficacy of the lamp. (2 marks)

(b) Pauline puts a book horizontally on the table at point *Y*. Neglect the size of the book.

(i) Find the illuminance on the book. (3 marks)

(ii) Without adding other light sources, suggest two methods that can increase the illuminance on the book. (2 marks)

(c) Spent CFLs should be recycled rather than disposed of directly. Explain briefly. (1 mark)

(d) If the CFLs are replaced by incandescent lamps with the same luminous flux but efficacy of 20 lm W^{-1}, what is difference in cost of electricity in using the lamps for 1200 hours? Each kW h of electricity costs $1.1. (2 marks)

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

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)
$E_n = -\frac{1}{n^2}\left\{\frac{m_e e^4}{8h^2\varepsilon_0^2}\right\} = -\frac{13.6}{n^2}\ \text{eV}$	energy level equation for hydrogen atom	$\text{power} = \frac{1}{f}$	power of a lens
$\lambda = \frac{h}{p} = \frac{h}{mv}$	de Broglie formula	$L = 10\log\frac{I}{I_0}$	intensity level (dB)
$\theta \approx \frac{1.22\lambda}{d}$	Rayleigh criterion (resolving power)	$Z = \rho c$	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