Form 6

Name:______________________

Class:________ No.: ______

Final Examination 2021/22
PHYSICS

Time Allowed: 2 hours 30 minutes

GENERAL INSTRUCTIONS

(1) There are TWO sections, A and B, in this Paper. You are advised to finish Section A in about 50 minutes.

(2) Section A consists of multiple-choice questions in this question book, while Section B contains conventional questions printed separately in Question-Answer Book B.

(3) Answers to Section A should be marked on the Multiple-choice Answer Sheet while answers to Section B should be written in the spaces provided in Question-Answer Book. The Answer Sheet for Section A and the Question-Answer Book for Section B will be collected separately at the end of the examination.

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

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

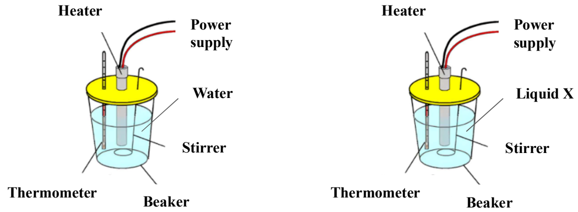
INSTRUCTIONS FOR SECTION A

1. Read carefully the instructions on the Answer Sheet. After the announcement of the start of the examination, you should first insert the information required in the spaces provided.
2. When told to open this book, you should check that all the questions are there. Look for the words 'END OF SECTION A' after the last question.
3. All questions carry equal marks.
4. ANSWER ALL QUESTIONS. You are advised to use an HB pencil to mark all the answers on the Answer Sheet, so that wrong marks can be completely erased with a clean rubber. You must mark the answers clearly; otherwise you will lose marks if the answers cannot be captured.
5. You should mark only ONE answer for each question. If you mark more than one answer, you will receive NO MARKS for that question.
6. No marks will be deducted for wrong answers.

Section A

There are 33 questions. Questions marked with * involve knowledge of the extension component.

1. Two identical heaters are immersed in two identical beakers, one containing 1 kg of liquid X and the other one containing 1 kg of water as shown. Both heaters are switched on for 10 minutes.
The specific heat capacity of liquid X is smaller than that of water.



Assuming no energy is lost to the surroundings. Which of the following statements is/are correct?

(1) Liquid X absorbs more energy from the heater than water does.
(2) The temperature rise of water is smaller than that of liquid X.
(3) If the masses of water and liquid X are both halved, the final temperature difference between water and liquid X will be halved.

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

2. 0.2 kg of water is heated to its boiling point by an immersion heater. The initial temperature of water is 20 °C. The mass of water remained in the beaker is 140 g after the immersion heater is switched on for 5 minutes. Assume that no energy lost to or gained from the surroundings, find the power of the immersion heater.
Neglect the heat capacity of the beaker. The specific heat capacity and specific latent heat of vaporization of water are 4200 J kg^{-1} $°C^{-1}$ and 2.26×10^6 J kg^{-1} respectively.

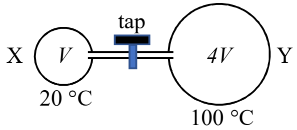
A. 676 W
B. 1 055 W
C. 1 279 W
D. 36 160 W

3. Milk at 10 °C is added to a cup of coffee at 80 °C. Assume that there is no heat exchange with the surroundings and neglect the heat capacity of the cup. Which of the following statements are correct?

(1) The energy lost by the coffee equals the energy gained by the milk.
(2) The average potential energy of the water molecules in the coffee decreases.
(3) The average kinetic energy of the water molecules in the coffee decreases.

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

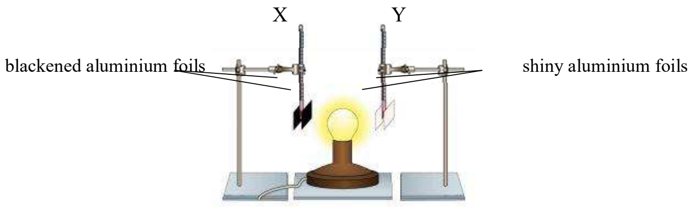
4. Two containers X and Y of volume V and 4V respectively are connected by a tube as shown below.

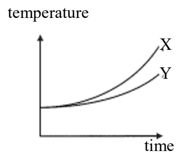


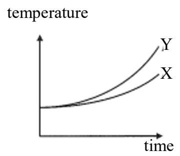
Initially, the tap is closed and an ideal gas is contained in X at 20 °C and 400 kPa. The same ideal gas is contained in Y at 100 °C and 100 kPa. The tap is then opened. Both containers X and Y are maintained at their initial temperatures throughout the process. What is the final pressure in Y?

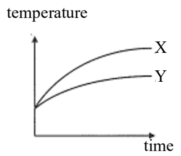
A. 140 kPa
B. 172 kPa
C. 187 kPa
D. 267 kPa

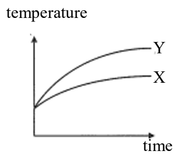
5. An experiment to study heat transfer is conducted. A light bulb is turned on and two thermometers A and B are clamped at the same distance from it. The thermometers are covered by two shiny aluminium foils and two blackened aluminium foils as shown in the figure below. The temperatures on both thermometers are recorded every minute. Which of the following graphs represents the variation of temperature against time?



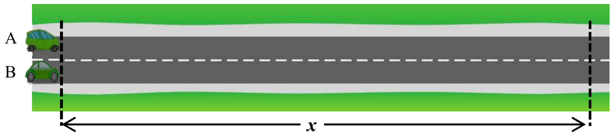
A.


B.


C.


D.


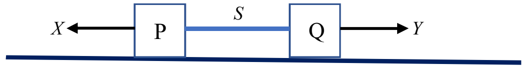
6. Cars A and B start from rest to move along a straight path of distance x to reach the destination. Car A accelerates uniformly for 5 seconds to attain a speed of 30 m s^{-1} while car B accelerates uniformly for 8 seconds to attain a speed of 40 m s^{-1}. Both cars travel with uniform velocities after acceleration.



If car B reaches the destination 1 second earlier than car A, find x.

A. 165 m
B. 180 m
C. 280 m
D. 300 m

7. As shown below, two blocks P and Q connected by a string S are placed on a horizontal frictionless surface. The masses of the blocks P and Q are $3m$ and $5m$ respectively. Two horizontal forces X and Y are applying by two strings on the blocks P and Q respectively (X > Y) such that the two blocks move with constant acceleration to the left. Find the tension of the string S.



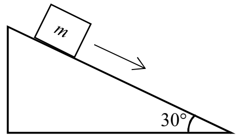
A. $\frac{3Y+5X}{8}$

B. $\frac{3X+5Y}{8}$

C. $\frac{5Y-3X}{8}$

D. $\frac{Y-X}{8}$

8. A block of mass m resting on a 30° incline is given a slight push and slides down the incline plane with a uniform speed. Which of the following statements about the block's motion on the incline are **incorrect**?



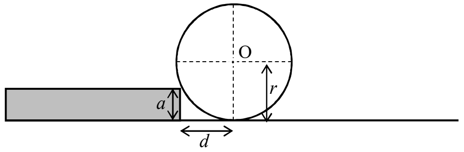
(1) The frictional force acting on the block is 0.866 mg.
(2) The net force acting on the block is 0.5 mg.
(3) If the block is given a greater initial speed, it will slide down the incline with acceleration.

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

9. An open truck moves with a uniform velocity on a frictionless horizontal surface. Rain falls into the truck with negligible speed at a rate of 45 kg per minute. To keep the truck in uniform motion, a 9 N horizontal force is needed to apply to it. Find the uniform speed of the truck.

A. 0.2 m s^{-1}
B. 5 m s^{-1}
C. 11.25 m s^{-1}
D. 12 m s^{-1}

10. The figure below shows a heavy cylinder with axle O, radius r and mass m. What is the minimum force (F_{min}) required to pull it on to the step?



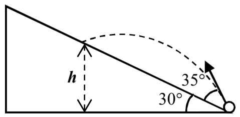
A. $\frac{mgd}{r}$

B. $\frac{mgd}{2r}$

C. $\frac{mgd}{(2r-a)}$

D. $\frac{mg(r-a)}{d}$

11. A ball is projected with an initial velocity 12 m s^{-1} along a plane. The plane makes an angle of 30° with horizontal and the ball is projected at an angle of 35° to the plane. What is the height (h) of the ball above the ground when it hits the plane?



A. 2.37 m

B. 3.52 m

C. 4.74 m

D. 9.48 m

12. A bullet of mass 0.02 kg is fired from a gun so that it moves with 800 m s^{-1} towards a wooden block. Assume the frictional force of the wooden block is constant. If the speed of the bullet is reduced by 100 m s^{-1} after penetrating through 20 cm, find the penetration depth of the bullet in the block.

A. 20.3 cm

B. 22.9 cm

C. 85.3 cm

D. 160 cm

13. During an alpha decay process, the following reaction occurs:

$$^{226}_{86}X \rightarrow {}^{222}_{84}Y + {}^{4}_{2}He$$

Initially, $^{226}_{86}X$ is at rest. It splits into two daughter nuclei, $^{222}_{84}Y$ and $^{4}_{2}He$. The masses of a proton and a neutron are 1.673 x 10^{-27} kg and 1.675 x 10^{-27} kg respectively. If the kinetic energy of $^{4}_{2}He$ is 7.6×10^{-13} J, which of the following statements is/are correct?

(1) The ratio of the speeds of $^{4}_{2}He$ and $^{222}_{84}Y$ is 2 : 111.

(2) The speed of $^{4}_{2}He$ is 1.51×10^{7} m s^{-1}.

(3) The kinetic energy of $^{4}_{2}He$ is greater than that of $^{222}_{84}Y$.

A. (l) only

B. (3) only

C. (l) and (2) only

D. (2) and (3) only

14. Satellites X and Y are orbiting around the Earth in circular orbits under the gravity of the Earth only. It is known that X is at a higher altitude. Which of the following statements must be correct? Assume that the Earth is a perfect sphere.

(1) The acceleration of X is smaller in magnitude.

(2) X has a higher orbital speed.

(3) Y has a higher angular speed.

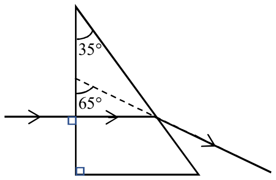
A. (1) and (2) only

B. (1) and (3) only

C. (2) and (3) only

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

15. A monochromatic light strikes a triangular glass prism as shown below.



Find the refractive index of glass.

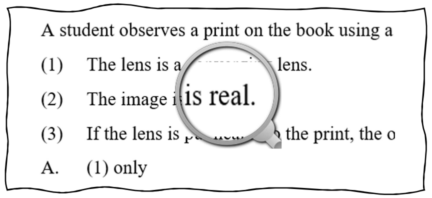
A. 1.51

B. 1.58

C. 1.72

D. 1.81

16.

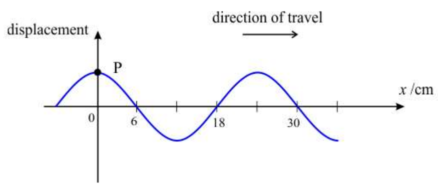


A student observes the words on the worksheet using a lens as shown above. Which of the following statements are **incorrect**?

(1) The image is real.
(2) The lens is a convex lens.
(3) If the lens is put nearer to the printing words, the observed image becomes larger.

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

17. The figure below shows displacement-distance graph of a section of a continuous transverse wave travelling along the x-direction at time $t = 0$.



At time $t = 2$ s, the particle P just passes the equilibrium position for a **third** time at that instant. Find the wave speed.

A. 9.6 cm s^{-1}
B. 12 cm s^{-1}
C. 15 cm s^{-1}
D. 18 cm s^{-1}

18. Which of the following statements about light is correct?

A. When light travels from water to air, its speed decreases.
B. When light travels from glass to water, its frequency increases.
C. Young's double slit experiment proves that light is a wave.
D. Diffraction of light can be observed through a 3 cm slit.

19. A beam of light strikes normally on a diffraction grating. If the angle between the two 2nd-order bright fringes is 46°, find the total number of bright fringes in the interference pattern.

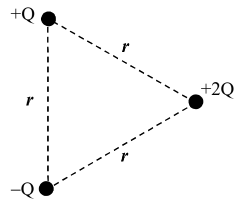
A. 5
B. 6
C. 10
D. 11

20. Which of the following statements about sound waves is/are correct?

(1) Sound wave can only travel in liquids and solids.
(2) Energy carried by the sound increases with its amplitude.
(3) Sound wave diffracts better than light wave as sound wave has a higher frequency.

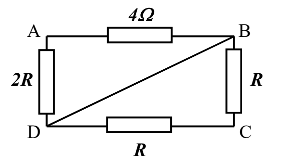
A. (1) only
B. (2) only
C. (1) and (3) only
D. (2) and (3) only

21. In the figure below, three charges are arranged on the vertices of an equilateral triangle of side length ***r***. If the magnitude of the electrostatic force acting on +Q is ***F***, find the magnitude of the electrostatic force acting on +2Q.



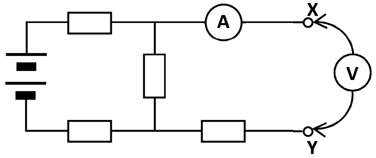
A. F
B. $\frac{2}{\sqrt{3}}F$
C. $\frac{\sqrt{3}}{2}F$
D. $\sqrt{3}F$

22. 4 resistors are connected in a circuit network as shown below. If the equivalent resistance across BC is 3 Ω, find the equivalent resistance across AC?



A. 2 Ω
B. 4 Ω
C. 6 Ω
D. 8 Ω

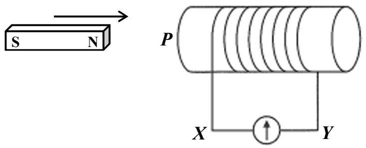
23. A battery of constant *e.m.f.* and negligible internal resistance is connected to four 8 Ω resistors and an ideal ammeter as shown below. If an ideal voltmeter is connected across XY, it reads 3 V.



What is the reading of the ammeter if XY is shorted?

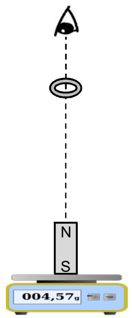
A. 0.225 A
B. 0.125 A
C. 0.09375 A
D. 0.0625 A

24. A magnet is accelerating towards a solenoid as shown below. Which of the following statements is correct?



A. The end of the coil marked ***P*** is a South pole.
B. Current flows through the galvanometer from ***X*** to ***Y***.
C. The deflection of the galvanometer is increasing.
D. The net force acting on the magnet is zero.

25. An aluminium ring is dropped over a bar magnet placed on a balance as shown on the right. Which of the following statements is/are correct?



(1) An induced current is flowing in anticlockwise direction in the iron ring when viewed from above.
(2) The reading of the balance remains constant before the ring rests on it.
(3) The temperature of the iron ring increases.

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

26. A sinusoidal a.c. of frequency ***f*** delivers a root-mean-square voltage $V_{r.m.s.}$. If its frequency is halved and its peak voltage is doubled, what would be the new root-mean-square voltage?

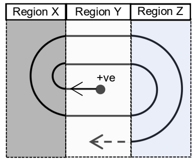
A. $\frac{1}{2\sqrt{2}}V_{r.m.s.}$

B. $\frac{1}{2}V_{r.m.s.}$

C. $\frac{1}{\sqrt{2}}V_0$

D. $\frac{2}{\sqrt{2}}V_0$

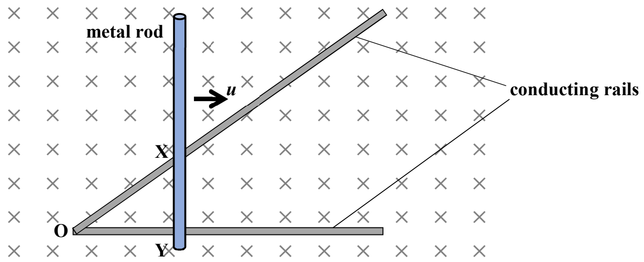
27. The diagram below shows the path of a positively charged particle inside the three regions X, Y and Z. Which of the following statements is/are the possible explanation for the path?



(1) In region X, a magnetic field is applied and points out of the paper.
(2) In region Y, the positively charged particle is accelerating.
(3) In region Z, an electric field is applied and points to the right.

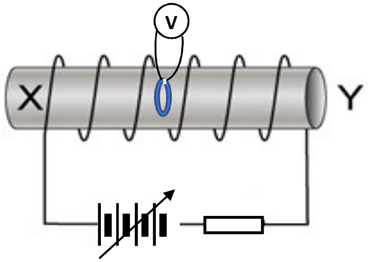
A. (2) only
B. (3) only
C. (1) and (2) only
D. (1) and (3) only

28. A metal rod is given a slight push to the right in a magnetic field as shown below. It then moves off with a initial velocity ***u*** to the right. Neglect the friction on the rails. Which of the following is correct?



A. The induced current is in direction **YXO**.
B. The rod will accelerate uniformly to the right.
C. The rod will move with a constant velocity.
D. The rod experiences a rightward force.

29. A solenoid of 200 turns, length 20 cm and diameter 40 cm is connected to a resistor and a variable d.c. supply as shown.



A circular coil of 10 turns and diameter 20 cm is placed in the mid-point of the solenoid and connected to a voltmeter. If the current flowing through the solenoid increases at a rate 5 A s^{-1}, what is the reading of the voltmeter? (Given: permeability of free space $\mu_o = 4\pi \times 10^{-7}$ m kg s^{-2} A^{-2})

A. 1.97 mV
B. 3.95 mV
C. 0.197 V
D. 0.395 V

30. Solution X contains a radioactive isotope of half-life 2.5 hours. At 9 am, 250 cm^3 of solution X, having an activity of 12800 Bq, is mixed with an unknown volume of pure water. At 7 pm, 25 cm^3 of the diluted solution is extracted and the activity is found to be 20 Bq. What is the volume of pure water used?

A. 500 cm^3
B. 750 cm^3
C. 1000 cm^3
D. 1250 cm^3

31. The half-life of a radioactive isotope X is double of that of a radioactive isotope Y. Which of the following statements is/are correct?

(1) The decay constant of X is half of that of Y.
(2) The activity of X is half of that of Y.
(3) The number of particles emitted by 1 g of X is smaller than that of 1 g of Y.

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

32. Which of the following is not a necessary condition for chain reaction of the fission of uranium to occur?

A. The mass of the uranium is large enough.
B. The number of neutrons generated exceeds the number of neutrons reacted.
C. The speed of the neutrons hitting uranium is slow enough.
D. The temperature is high enough.

33. A reaction is represented by the nuclear equation is shown below.

$$^{2}_{1}H + ^{3}_{1}H \longrightarrow ^{4}_{2}He + ^{1}_{0}n$$

The energy yielded is 17.6 MeV. How is the total mass of the constituents on the right compared with that on the left?

A. The total mass on the left is 1.96×10^{-10} kg less.
B. The total mass on the right is 1.96×10^{-10} kg less.
C. The total mass on the left is 0.0189 u more.
D. The total mass on the right is 0.0189 u more.

~ End of section A ~

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	$\text{pc} = 3.09 \times 10^{16}\ \text{m} = 3.26\ \text{ly} = 206\ 265\ \text{AU}$
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
$P = \frac{1}{2}\rho A v^3$	maximum power by wind turbine

Atomic World

$\frac{1}{2}m_e {v_{max}}^2 = hf - \phi$	Einstein's photoelectric equation
$E_n = -\frac{1}{n^2}\left\{\frac{m_e e^4}{8h^2{\varepsilon_0}^2}\right\} = -\frac{13.6}{n^2}\ \text{eV}$	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.	$F = \frac{Gm_1 m_2}{r^2}$	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.	$F = \frac{Q_1 Q_2}{4\pi\varepsilon_0 r^2}$	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

Form 6

Name:______________________

Class:________ No.: ______

Form 6 PHYSICS
2021 - 2022

Final Examination

SECTION B: Question-Answer Book B

This paper must be answered in English

INSTRUCTIONS FOR SECTION B

(1) After the announcement of the start of the examination, you should first insert your information in the spaces provided on Page 1.

(2) Refer to the general instructions on the cover of the Question Paper for Section A.

(3) Answer **ALL** questions.

(4) Write your answers of Section B in the spaces provided in this Question-Answer Book. Do not write in the margins. Answers written in the margins will not be marked.

(5) Graph paper and supplementary answer sheets will be provided on request. Insert the information required, mark the question number box, and attach them INSIDE this Question-Answer Book.

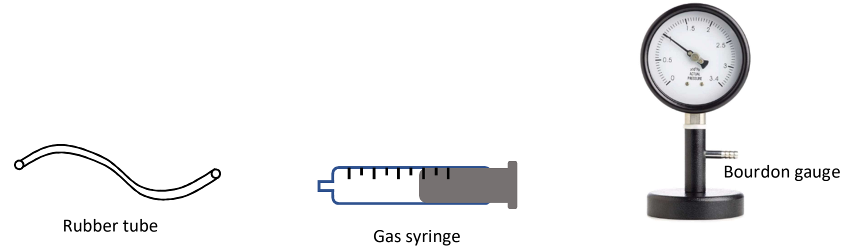
(6) No extra time will be given for inserting your information after the 'Time is up' announcement.

Marker' s Use Only

Question No.	Marks
1	/ 7
2	/ 6
3	/ 8
4	/ 8
5	/ 6
6	/ 10
7	/ 8
8	/ 8
9	/ 8
10	/ 8
11	/ 7
Total	**/ 84**

Section	Marks
A	
B	

Q.1 You are given the instruments below to investigate the relationship between the volume and pressure of a gas.

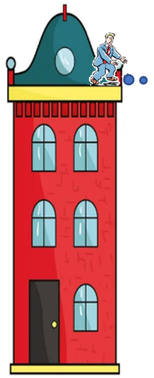


(a) Describe how you can use the given instruments to investigate the Boyle's law. (4 marks)

(b) State the two physical variables that are fixed in the experiment. (1 mark)

(c) Explain Boyle's law in terms of the kinetic theory. (2 marks)

Q.2 In the 16th century, a famous scientist performed an experiment by dropping two objects of different masses simultaneously from the top of a high building. It was found that both objects hit the ground at the same time.



(a) If the above experiment is carried out using modern timing equipment, it is found that the heavier object reaches the ground slightly sooner than the lighter one. Explain why. (2 marks)

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(b) When a heavy object is released from the top of the building, it takes 1.79 s to reach the ground. The height of the building is 15.6 m. Assume the object accelerates uniformly throughout its motion.

(i) Calculate the speed of the object when it reaches the ground. (2 marks)

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(ii) The mass of the heavy object is found to be 3.58 kg. How much mechanical energy is lost during the downward motion? (2 marks)

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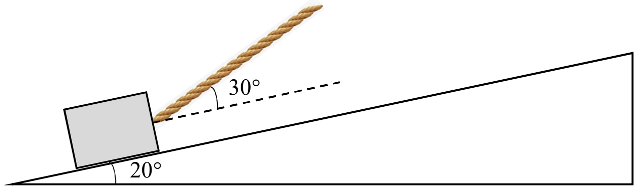
Q.3 A block of mass 3 kg is pulled by a rope up an inclined plane at 20° to the horizontal. The rope makes an angle at 30° to the inclined plane as shown. The friction between the block and the plane is 12 N. The block moves from rest with an acceleration of 0.5 m s^{-2} for 5 seconds up the plane.



(a) Find the tension in the rope. (2 marks)

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(b) Find the normal force acting on the block by the inclined plane. (2 marks)

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(c) After moving for 5 seconds, the rope suddenly breaks. Find the speed of the block just after the rope breaks. (2 marks)

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(d) Describe the subsequent motion of the block after the rope breaks. (2 marks)

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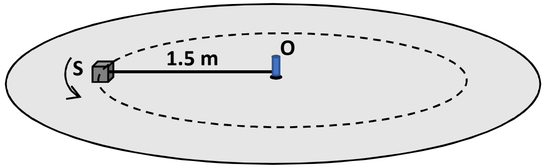
Q.4 An object ***S*** is connected to a fixed point O by an inextensible light string on a smooth horizontal table as shown. The string is 1.5 m long. The object completes 5 revolutions in 2 s.



The object breaks up into two parts A and B suddenly. Parts A and B are 1 kg and 2 kg respectively. Both parts move along the original moving direction just after breaking. Part A remains attached to the string after breaking.

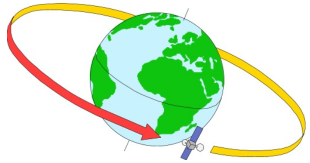
(a) Find the linear speed of the object before breaking. (2 marks)

(b) After breaking, the tension in the string becomes 2 times the original value. Find the corresponding linear speed of part A. (3 marks)

(c) Find the speed of part B just after breaking. (2 marks)

(d) If the object breaks at point S, **sketch** the subsequent motion of part B in the above diagram. (1 mark)

Q.5 A satellite is orbiting around the Earth at a distance of 1200 km above the surface. The mass of the satellite is 6000 kg. Take the acceleration due to gravity at the Earth's surface as 9.81 m s^{-2} and the Earth's radius as 6370 km.

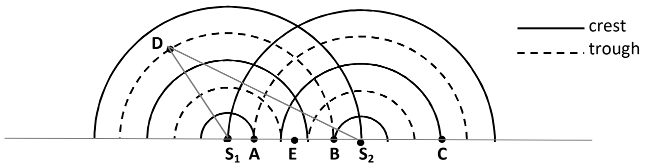


(a) Find the orbital speed of the satellite. (2 marks)

(b) What is the kinetic energy of the satellite? (2 marks)

(c) If the orbital radius of the satellite is halved, find the new kinetic energy of the satellite. (2 marks)

Q.6 Two vibrators S_1 and S_2 are set up in a ripple tank to demonstrate interference. They vibrate in phase to produce two circular water waves of wavelength 8 cm. The figure below shows the wave pattern produced at time t = 0 s.



(a) (i) Point C is on the line joining S_1 and S_2 as shown. Which kind of interference occurs at C? Briefly explain. (2 marks)

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(ii) If point D is a 2^{nd}-order maximum, find the lengths of S_1D and S_2D. (1 mark)

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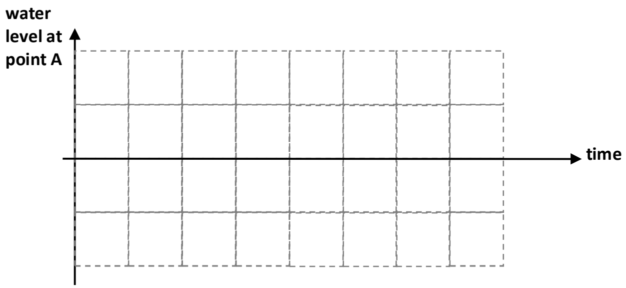
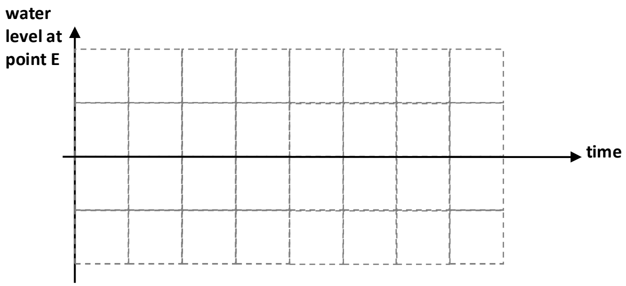
(b) (i) Sketch the water level at point A against time (for 2 periods). (1 mark)



(ii) Sketch the water level at point E against time (for 2 periods). (1 mark)



Q.6

(c) If the vibrators in the experiment are replaced by two identical monochromatic light sources and placed in front of a screen, can we obtain an observable interference pattern on the screen? Explain your answer briefly. (2 marks)

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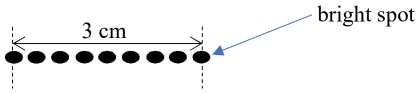
(d) A double-slit and a point light source of frequency 6.7×10^{14} Hz are used to demonstrate the interference of light. The screen is placed 5 m away from the double-slit. The fringe pattern on the screen is shown below.



Find the wavelength of the light from the source. Estimate the slit separation. (3 marks)

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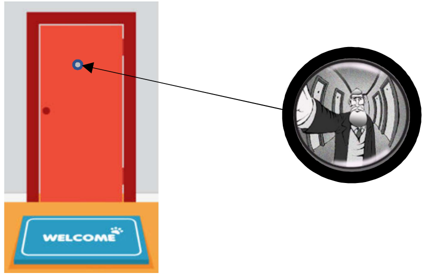
Q.7 The diagram below shows a peephole on a door and the image seen through it.

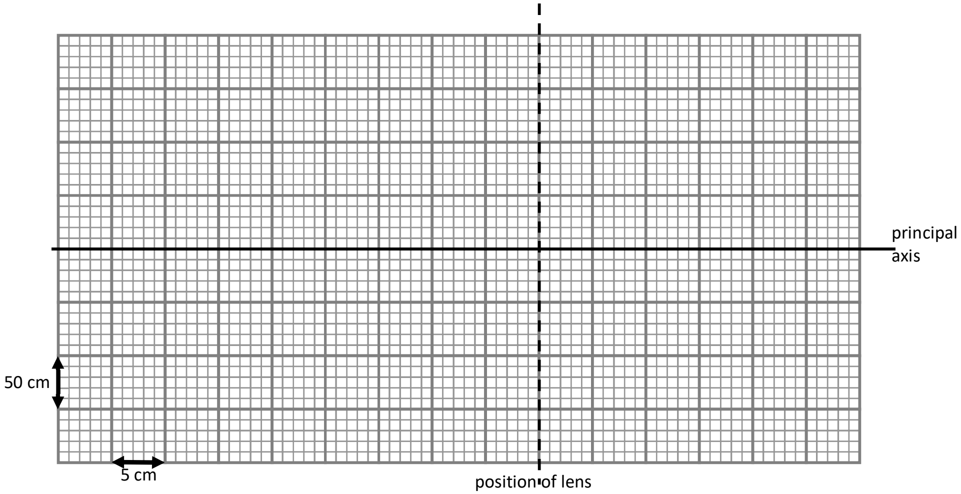


(a) What kind of lens is used in a peephole? State one advantage of using this kind of lens. (2 marks)

(b) When a man of height 1.8 m stands 36 cm in front of the door, the image formed by the lens of the peephole is just 0.4 m.

(i) Find the linear magnification of the image. (1 mark)

(ii) Draw a ray diagram on the graph below to find the focal length of the lens used. (3 marks)



Focal length of the lens in part (a) is _______________ . (1 mark)

(c) State one advantage of using a lens with shorter focal length in the peephole. (1 mark)

Q.8 A 3-A fuse is connected in an electrical circuit. A current of 5 A passes through the circuit suddenly. A particular part of the fuse wire, with latent heat of fusion 20 J, melts and breaks the circuit. The room temperature is 20 °C.

Specifications:
- Diameter: 0.5 mm
- Length: 1.2 cm
- Resistivity: 2.50×10^{-5} Ω m
- Melting point: 58 °C
- Heat capacity: 0.085 J °C^{-1}

(a) Find the total amount of energy required to melt that segment of the fuse wire. (2 marks)

(b) Find the resistance of the fuse wire. (2 marks)

(c) Find the amount of time required to break the circuit. (4 marks)

Q.9 An ideal transformer has 3000 turns in the primary coil and 200 turns in the secondary coil. The primary coil is connected to the 220-V mains supply via a 2-A fuse.

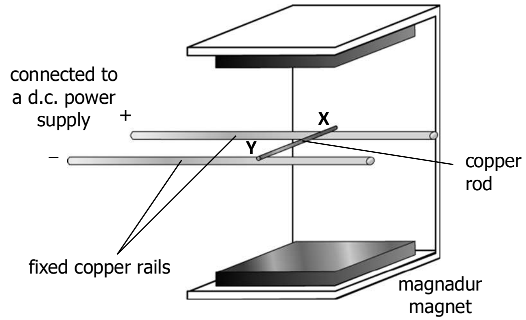
(a) What is the current through the secondary coil when it is connected to a 20-Ω light bulb? (2 marks)

(b) Hence, find the current through the primary coil. (2 marks)

(c) What is the maximum number of 20-Ω light bulbs that can be connected in parallel to the secondary coil without blowing the fuse? (2 marks)

(d) For the 20-Ω light bulb to light up, the minimum operating current is 0.08 A. What is the maximum number of light bulbs that can be connected in series to the secondary coil? (2 marks)

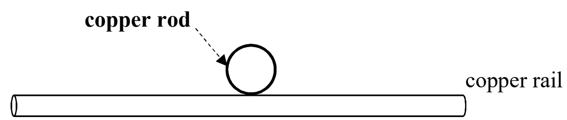
Q.10



In a magnetic field produced by a magnadur magnet, a copper rod is resting on two fixed parallel and horizontal rails as shown. When the d.c. power supply is switched on, the copper rod moves to the right at a uniform speed.

(a) State the direction of the magnetic field of the magnadur magnet. (1 mark)

(b) Draw a free body diagram to show all the forces acting on the copper rod. (2 marks)



(c) The current drawn from the d.c. power supply is 1.2 A and the magnetic field of the magnadur magnet is 0.5 T. The length of XY is 10 cm. Find the friction acting on the copper rod. (2 marks)

(d) What happens to the rod when the d.c. power supply is switched off suddenly? Explain and describe briefly. (2 marks)

(e) At the instant the supply is switched off, which end, X or Y is at a higher potential? (1 mark)

Q.11

$$^{210}_{83}\text{Bi} \rightarrow {}^{b}_{a}\text{X} + {}^{4}_{2}\text{He}$$

A source contains radioactive nuclide Bi-210. Bi-210 underwent alpha decay and became ***X*** as shown in the above equation. In this reaction, 8.49×10^{-13} J of energy was released. The half-life of Bi-210 is 5.01 days. The initial activity of the source is 16 800 Bq.

Given: Mass of Bi-210 = 209.9841 u — Mass of alpha particle = 4.0015 u

$1 \text{ u} = 1.661 \times 10^{-27}$ kg — Speed of light = 3×10^{8} m s^{-1}

(a) Find ***a*** and ***b***. (1 mark)

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(b) Find the mass of ***X*** (in terms of u). (2 marks)

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(c) Find the decay constant of Bi-210. (1 mark)

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(d) Find the initial number of Bi-210 nuclides. (1 mark)

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(e) Find the total energy released by the source in 10 days. (2 marks)

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~ End of paper ~

Form 6 **Name: ____________________**

Class: _______ No:______

Final Examination 2021/22

PHYSICS PAPER 2

Question-Answer Book
Time allowed: 1 hour

INSTRUCTIONS

1. After the announcement of the start of the examination, you should first write your name, class and class number in the space provided on Page 1 and the answer book.
2. This paper consists of THREE sections, sections 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 Name, Class, Class Number and Question Number on each sheet.
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.

Section B: Atomic World		
	Full Marks	Marks
MC	8	
SQ	10	
Section C: Energy and Use of Energy		
	Full Marks	Marks
MC	8	
SQ	10	
Section D: Medical Physics		
	Full Marks	Marks
MC	8	
SQ	10	

Paper 2 Total		
	Full Marks	Marks
	40	

Section B: Atomic World

Q.2: Multiple-choice questions

2.1 The ionization energy of a hydrogen atom is 13.6 eV. Which of the following photon(s) may excite a hydrogen atom from the ground state to the first excited state?

(1) A photon with energy 3.4 eV
(2) A photon with energy 10.2 eV
(3) A photon with energy 12.1 eV

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

A B C D
○ ○ ○ ○

2.2 Which of the following can be explained by the Bohr's model?

(1) The ionization energy of a hydrogen atom is 13.6 eV.
(2) Discrete bright lines are observed in the emission spectrum of hydrogen atom.
(3) Dark lines are observed in the absorption spectrum of hydrogen atom.

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 Which of the following best explains the way that α particles are deflected in Rutherford's α-particle scattering experiment?

A. There is gravitational force between the α particle and the gold nucleus.
B. Most of the mass of a gold atom is concentrated in a tiny volume at the centre.
C. Electrons are unevenly distributed inside a gold atom.
D. Many electrons orbit a gold nucleus.

A B C D
○ ○ ○ ○

2.4 Which of the following postulates of the Bohr's model of the hydrogen atom is/are 'quantum'?

(1) The electron is moving around the nucleus in a circular orbit.
(2) The total energy of the electron staying in its orbit remains unchanged.
(3) The electron can only occupy certain discrete orbits.

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 The apertures and the de Broglie wavelengths of the electrons used in four transmission electron microscopes are shown below.

microscope	aperture / μm	de Broglie wavelength of the electrons used / nm
P	35	0.0040
Q	35	0.0060
R	30	0.0060
S	40	0.0070

Assume that the resolving power of a microscope is only limited by diffraction. Which of the following microscopes has the smallest minimum resolvable angular separation?

A. *P*
B. *Q*
C. *R*
D. *S*

A B C D

2.6 Which of the following properties of a specimen affects whether it can be observed under a scanning tunnelling microscope?

A. colour
B. thickness
C. thermal conductivity
D. electrical conductivity

A B C D

2.7 A metal of work function 5.55 eV is exposed to an electromagnetic radiation of frequency 6.89×10^{15} Hz. Find the stopping potential.

A. 23.0 V
B. 24.9 V
C. 28.6 V
D. 30.3 V

A B C D

2.8 In an experiment on the photoelectric effect, electrons are emitted when the metal plate of a photocell is illuminated by yellow light. Which of the following statements about the experiment **must** be correct?

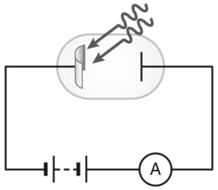
(1) Electrons will also be emitted if the yellow light is replaced by red light.
(2) Electrons are emitted almost immediately after the illumination.
(3) The maximum kinetic energy of the electrons is independent of the intensity of the light used.

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

A B C D

Q.2: Structured question

In a photoelectric experiment, a calcium metal plate of area 3×10^{-4} m^2 is illuminated by a beam of violet light of intensity 0.032 W m^{-2} as shown.



The maximum KE of the photoelectrons is 0.95 eV. The work function of calcium is 2.87 eV.

Take $e = 1.6 \times 10^{-19}$ C.

(a) Find the energy (in eV) of the photons of the beam of violet light. (1 mark)

(b) Explain why not all the emitted photoelectrons possess the maximum KE. (1 mark)

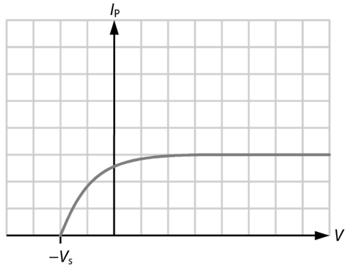
(c) (i) Estimate, using the classical wave theory, the minimum time required for a calcium atom to absorb enough energy to eject an electron. Take the effective area of a calcium atom in absorbing energy as 0.2 nm^2. (2 marks)

(ii) The experiment shows that the emission of photoelectrons is immediate even though the intensity of the beam is weak. Why? (1 mark)

(d) (i) How many photons fall on the calcium surface in each second? (1 mark)

(ii) If only 5% of the photons can cause the emission of photoelectrons, estimate the maximum photocurrent produced. (2 marks)

(e) The graph below shows how the photocurrent I_P changes with the applied voltage V where V_s is the stopping potential.



On the same graph, draw the I_P–V graph (in dotted line) that would be obtained if the intensity of the light is doubled. (2 marks)

Section C: Energy and Use of Energy

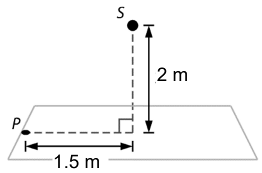
Q.3: Multiple-choice questions

3.1 The rated power and COP of an air conditioner are 1.25 kW and 3.2 respectively. Estimate the maximum amount of energy released to the outside by the air conditioner in 2 hours.

A. 2.5 kW h
B. 4.0 kW h
C. 8.0 kW h
D. 10.5 kW h

A B C D
○ ○ ○ ○

3.2 A point light source S is at the centre of the celling in a room of dimensions 2 m × 3 m × 3 m. It gives an illuminance of 30 lux at a tiny surface P on the floor as shown.

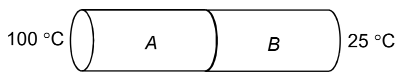


Estimate the luminous flux produced by the source. Neglect reflections of light.

A. 2360 lm
B. 2950 lm
C. 3930 lm
D. 5890 lm

A B C D
○ ○ ○ ○

3.3 A rod is made of two kinds of materials A and B as shown below. The two parts have the same length and radius. The thermal conductivity of A is twice that of B. The temperatures at the two ends of the rod are maintained at 100 °C and 25 °C respectively. What is the temperature at the interface between A and B after the temperature becomes steady?



A. 50.0 °C
B. 62.5 °C
C. 75.0 °C
D. 87.5 °C

A B C D
○ ○ ○ ○

3.4 A wind turbine has 3 blades of length 4 m. Wind is blowing head-on at a velocity of 6 m s^{-1}. The efficiency of generating electricity is 25%. The density of air is 1.3 kg m^{-3}. How many 60 W light bulbs can be operated at the same time?

A. 29
B. 58
C. 88
D. 116

A B C D
○ ○ ○ ○

3.5 The Overall Thermal Transfer Value (OTTV) of a building can be reduced by

(1) applying external shades to windows.
(2) installing curtain or blinds.
(3) designing building with a high windows-to-wall ratio.

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

A B C D
○ ○ ○ ○

3.6 Which of the following statements about a fossil-fuel vehicle are incorrect?

(1) It does not give out air pollutants.
(2) Its end-use energy efficiency is higher than that of an electric vehicle.
(3) It has a larger combustion engine than an electric vehicle of a similar size.

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

A B C D
○ ○ ○ ○

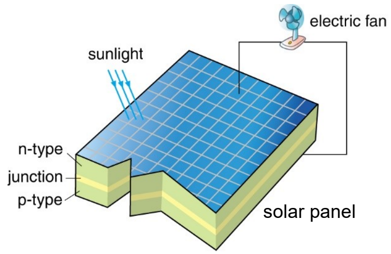
3.7 Which of the following is/are (an) advantage(s) of an electric hotplate over an induction cooker?

(1) An electric hotplate is more energy efficient.
(2) An electric hotplate heats food without generating heat itself.
(3) An electric hotplate can be used with non-metallic pots.

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

A B C D
○ ○ ○ ○

3.8 A solar panel is connected to an electric fan as shown. The fan operates when sunlight falls on the solar panel.



Which of the following statements is/are correct?

(1) Free electrons and holes are created in the junction region.
(2) Free electrons leave the panel from the n-type region.
(3) The panel remains electrically neutral.

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

A B C D
○ ○ ○ ○

Q.3: Structured question

An interior designer is designing an environmentally friendly warehouse in the city. The rate of heat transfer between the interior and the exterior of the warehouse is designed to be as low as possible.

(a) The designer uses a low-e glass for the windows of the warehouse. Explain why this kind of glass can help reduce the rate of heat transfer. (2 marks)

(b) The designer claims that the insulation of the roof of the warehouse is more important than that of the walls.

(i) Explain why the insulation of the roof is more important. (1 mark)

(ii) The designer installed a layer of insulation board which is made of polystyrene on the interior of the roof. The following figure shows the cross-section of the insulating board.

Describe how this material can reduce the rate of heat transfer through the roof. (2 marks)

(c) The following table lists the total area of the concrete walls, the roof and the glass of the warehouse and their corresponding U-values.

Component	Total Area / m^2	U-value / $W\ m^{-2}\ K^{-1}$
concrete wall	360	0.9
roof	216	0.3
glass	36	2.5

The temperature of the interior and exterior 20 °C and 35 °C respectively. The average rate of heat transfer into the warehouse by radiation is 100 W m^{-2}.

(i) Find the overall rate of heat gained by the warehouse through the building envelope. (2 marks)

(ii) Hence, find the OTTV of the warehouse. (1 mark)

An air-conditioning system is used to maintain the temperature inside the warehouse at 20 °C. The coefficient of performance (COP) of the air-conditioning system is 3.5.

(d) What is the input power of the air-conditioning system? (1 mark)

(e) Suggest a method to reduce the electrical energy consumption of the air-conditioning system. (1 mark)
[*Remark: The temperature of the warehouse has to be maintained at 20 °C.*]

Section D: Medical Physics

Q.4: Multiple-choice questions

4.1 Peter has a defective eye whose near point is at 50 cm. He can see objects at 25 cm clearly with a spectacle lens. The spectacle lens is 2 cm from the eye. Peter now switches from a spectacle lens to a contact lens. Which of the following statements are correct?

(1) Peter is suffering from short sight.
(2) The focal length of the spectacle lens is 44.2 cm.
(3) The focal length of the spectacle lens is longer than that of the contact lens.

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

A B C D
○ ○ ○ ○

4.2 Refer to the Rayleigh criterion, under which of the following conditions will the resolving power be the best? Assume that all points are of equal separation at the same distance away. (*Aperture can be defined as the opening in a lens through which light passes to enter the camera.*)

A. Two blue points observed by a telescope of large aperture
B. Two red points observed by a telescope of small aperture
C. Two blue points observed by a telescope of small aperture
D. Two red points observed by a telescope of large aperture

A B C D
○ ○ ○ ○

4.3 What is the **major** function of the eardrum?

A. It converts the vibration of air to the vibration of the ear bones.
B. It converts the mechanical vibrations to signals for the nerves.
C. It separates the middle ear and the inner ear.
D. It amplifies the sound incident on it.

A B C D
○ ○ ○ ○

4.4 In an ultrasound scan, an ultrasound wave with a higher frequency

A. penetrates deeper into body tissues.
B. provides a higher resolution of the images.
C. travels faster in body tissues.
D. has a larger power.

A B C D
○ ○ ○ ○

4.5 The half-value thickness of an aluminium plate is 3 mm. Which of the following statements is/are correct?

(1) The intensity of an X-ray can be reduced to zero by using two 3 mm aluminium plates.
(2) The intensity of an X-ray will be reduced to its half after the X-ray passes through a 3 mm aluminium plate.
(3) The linear attenuation coefficient is directly proportional to the half-value thickness of aluminium.

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

A B C D
○ ○ ○ ○

4.6 Which of the following statements about artificial contrast media is / are correct?

(1) They can be taken in through injection only.
(2) They have higher attenuation coefficients than soft tissues do.
(3) They allow an organ to appear whiter on an X-ray image.

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

A B C D
○ ○ ○ ○

4.7 An aluminium plate of thickness 2 mm can reduce the intensity of an X-ray by 37%. What is the percentage reduction in the intensity after the X-ray passes through an aluminium plate of thickness 8 mm?

A. 39.7%
B. 60.3%
C. 74.0%
D. 84.3%

A B C D
○ ○ ○ ○

4.8 Which of the following are the processes involved in reconstructing a 3D image in a CT scan?

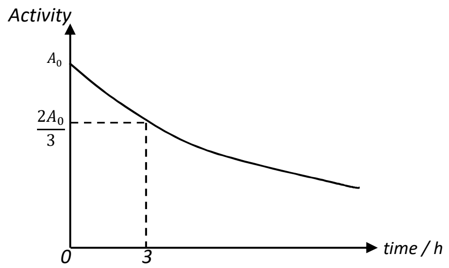
(1) A one-dimensional X-ray scan is performed.
(2) Multiple X-ray scans on the same plane to form a 2D scan slice.
(3) Stacking up of slices gives a 3D model.

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.4: Structured question

A radioactive tracer is injected into a patient's body. The activity of the tracer inside the patient's body at different time is shown below.



(a) Find the effective decay constant and effective half-life of the radioactive tracer. (2 marks)

(b) Given that the biological half-life of the tracer is 12 hours. Find its physical half-life.(2 marks)

(c) When will the activity drop to $\frac{1}{100}A_0$? (2 marks)

A man feels pain in his chest and is suspected to suffer from bone fracture. He then consults a doctor. The doctor runs some diagnostic tests to check his health condition.

(d) What kind of medical imaging should the man receive first? (1 mark)

After taking the imaging in (d), the doctor finds that the man's bones are fine. The doctor then suggests the man to have a check on soft tissues.

(e) Suggest a kind of medical imaging method to serve this purpose. (1 mark)

(f) Why is it appropriate for the doctor suggesting to use the imaging method mentioned in (d) first before using the method in (e)? Explain briefly. (2 marks)

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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	$e = 1.60 \times 10^{-19}$ C	
electron rest mass	$m_e = 9.11 \times 10^{-31}$ 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	$u = 1.661 \times 10^{-27}$ kg	(1 u is equivalent to 931 MeV)
astronomical unit	$AU = 1.50 \times 10^{11}$ m	
light year	$ly = 9.46 \times 10^{15}$ m	
parsec	$pc = 3.09 \times 10^{16} \text{ m} = 3.26 \text{ ly} = 206\,265 \text{ AU}$	
Stefan constant	$\sigma = 5.67 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$	
Planck constant	$h = 6.63 \times 10^{-34}$ 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
$E_n = -\frac{1}{n^2}\left\{\frac{m_e e^4}{8h^2\varepsilon_0^2}\right\} = -\frac{13.6}{n^2}$ eV	energy level equation for hydrogen
$\lambda = \frac{h}{p} = \frac{h}{mv}$	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

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