

**Physics**  
**Higher level**  
**Paper 1**

2 May 2023

Zone A afternoon | Zone B morning | Zone C morning

1 hour

---

**Instructions to candidates**

- Do not open this examination paper until instructed to do so.
- Answer all the questions.
- For each question, choose the answer you consider to be the best and indicate your choice on the answer sheet provided.
- A clean copy of the **physics data booklet** is required for this paper.
- The maximum mark for this examination paper is **[40 marks]**.



21 pages

2223-6513  
© International Baccalaureate Organization 2023

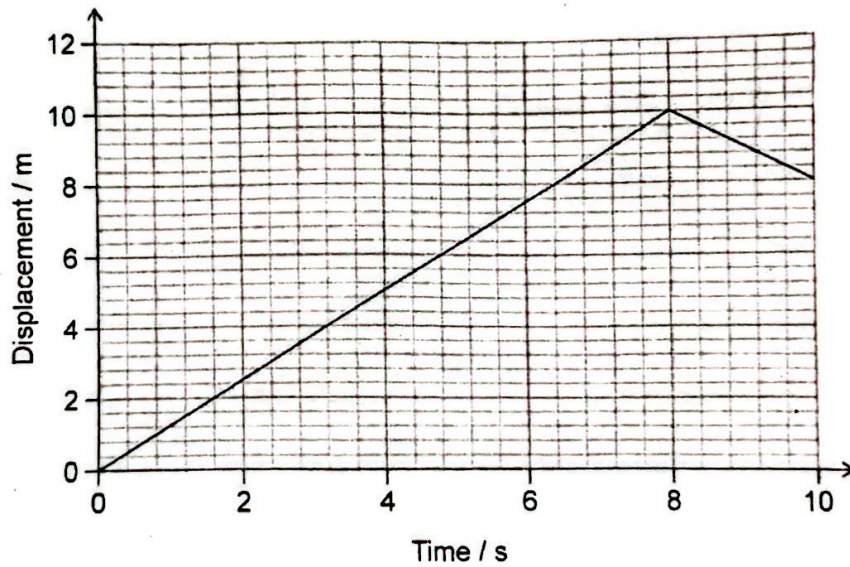
1. A rocket travels a distance of 3 km in 10 s.

What is the order of magnitude of  $\frac{\text{the speed of the rocket}}{\text{the speed of light in a vacuum}}$  ?

- A. -5
- B. -6
- C. -7
- D. -8

$$\frac{10^{-1}}{10^8}$$

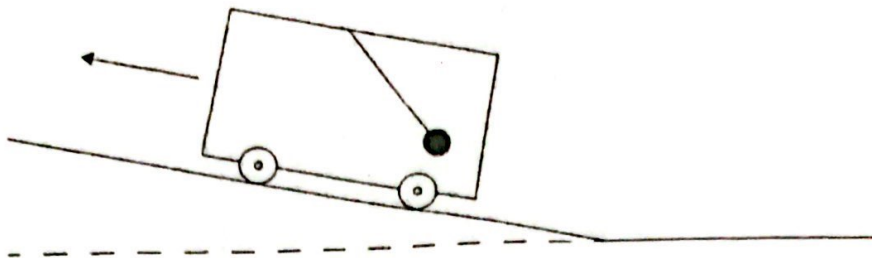
2. The variation with time of the displacement of an object is shown.



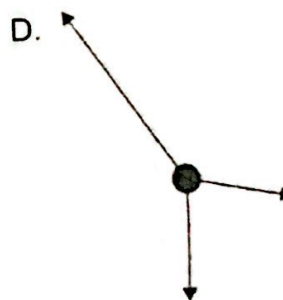
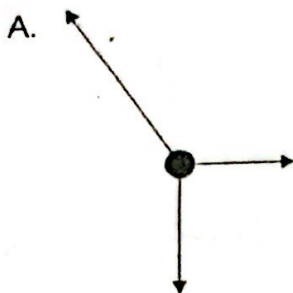
What are the average speed and average velocity of the object over the 10 s time interval?

	Average speed / $\text{ms}^{-1}$	Average velocity / $\text{ms}^{-1}$
A.	0.8	0.8
B.	0.8	1.2
C.	1.2	0.8
D.	1.2	1.2

3. A mass is suspended by a light string from the roof of a car. The car is accelerating up an incline.



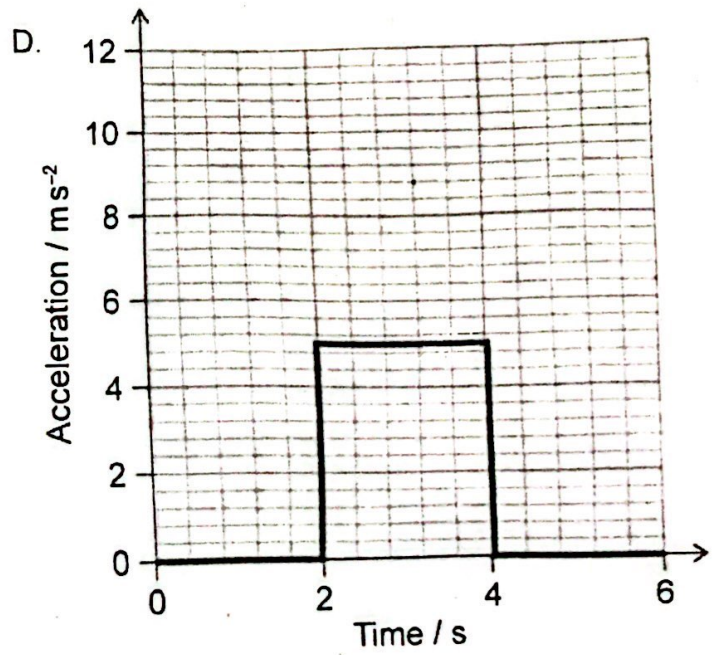
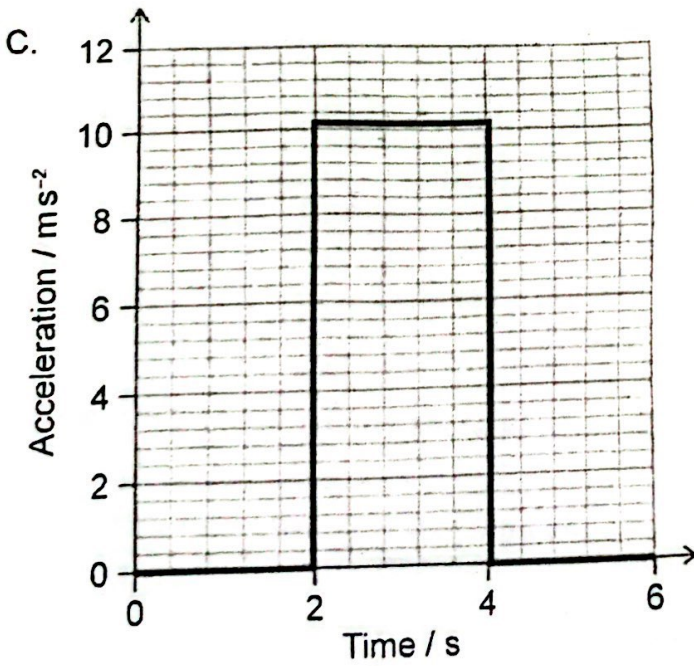
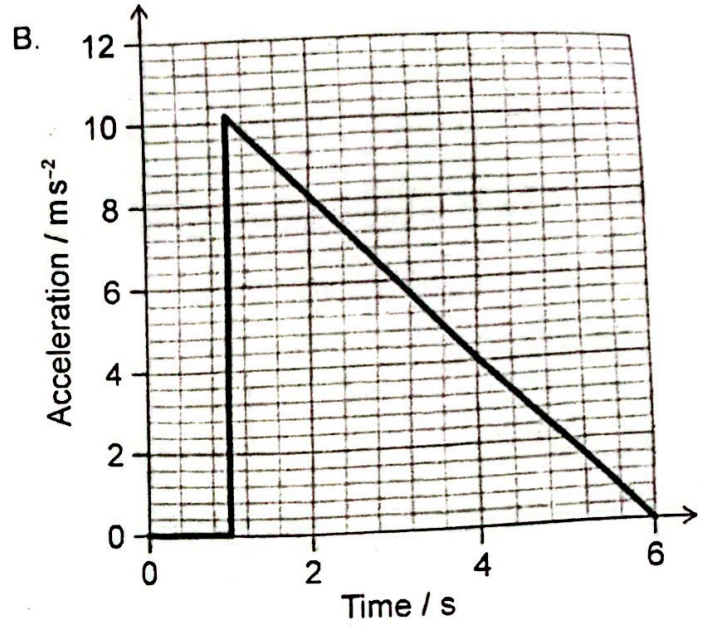
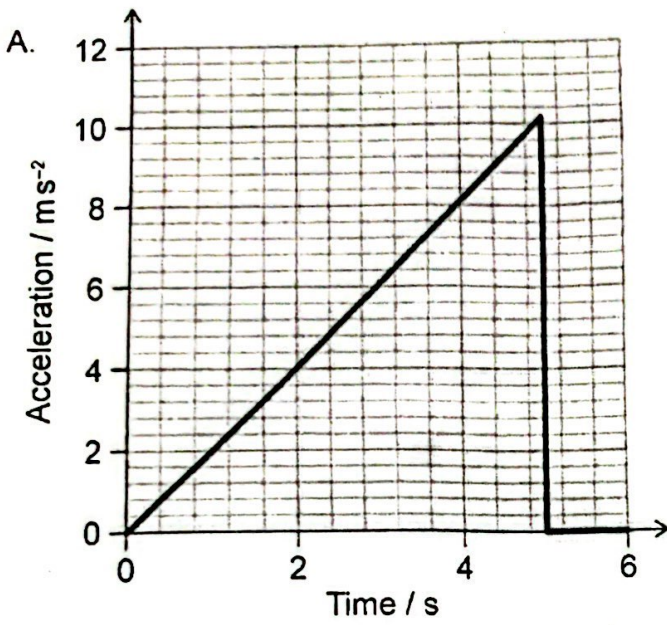
What is the free-body diagram for the mass?



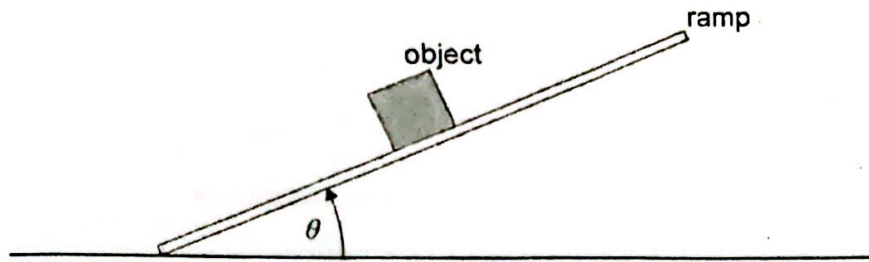
4. An object is travelling with velocity  $5 \text{ m s}^{-1}$ . The object then accelerates to  $15 \text{ m s}^{-1}$  in the same direction.

What is the variation with time of the acceleration of the object?

5. The angle  $\theta$  on the ramp

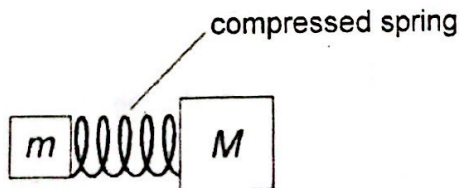


5. The angle  $\theta$  between a ramp and a horizontal surface slowly increases from zero. An object on the ramp does not slide as  $\theta$  increases.



The frictional force on the object is

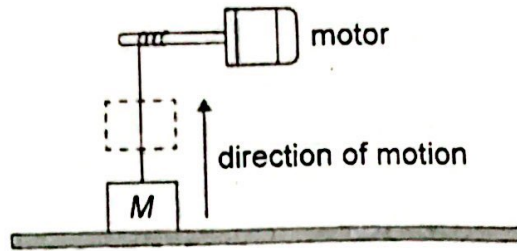
- A. constant.
  - B. negligible.
  - C. proportional to  $\cos \theta$ .
  - D. proportional to  $\sin \theta$ .
6. A spring of negligible mass is compressed and placed between two stationary masses  $m$  and  $M$ . The mass of  $M$  is twice that of  $m$ . The spring is released so that the masses move in opposite directions.



What is  $\frac{\text{kinetic energy of } m}{\text{kinetic energy of } M}$ ?

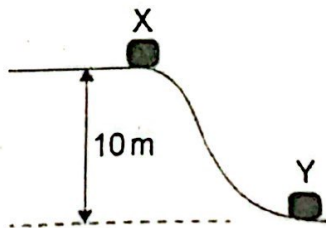
- A.  $\frac{1}{2}$
- B. 1
- C. 2
- D. 4

7. An object of mass  $M$  is accelerated vertically upwards by a motor. The object is initially at rest and reaches a vertical speed of  $4.0 \text{ m s}^{-1}$  in  $2.0 \text{ s}$ .



What is the average power output of the motor?

- A.  $8M$
  - B.  $24M$
  - C.  $32M$
  - D.  $48M$
8. An object is released from rest at X and slides to Y. The vertical distance between X and Y is  $10 \text{ m}$ . During the motion,  $20\%$  of the object's initial gravitational potential energy is lost as friction.



What is the speed of the object at Y?

- A.  $\frac{16}{\sqrt{g}}$
- B.  $2\sqrt{g}$
- C.  $4\sqrt{g}$
- D.  $8g$

9. A fixed mass of an ideal gas expands slowly at constant temperature in a container.

Three statements about the gas molecules during the expansion are:

- I. They collide with the walls of the container at a reduced rate.
- II. They travel further on average between each collision.
- III. Their average kinetic energy decreases as the gas expands.

Which statements are correct?

- A. I and II only
  - B. I and III only
  - C. II and III only
  - D. I, II and III
10. A balloon of volume  $V$  contains 10 mg of an ideal gas at a pressure  $P$ . An additional mass of the gas is added without changing the temperature of the balloon. This change causes the volume to increase to  $2V$  and the pressure to increase to  $3P$ .

What is the mass of gas added to the balloon?

- A. 5 mg
  - B. 15 mg
  - C. 50 mg
  - D. 60 mg
11. A pipe containing air is closed at one end and open at the other. The third harmonic standing wave for this pipe has a frequency of 150 Hz.

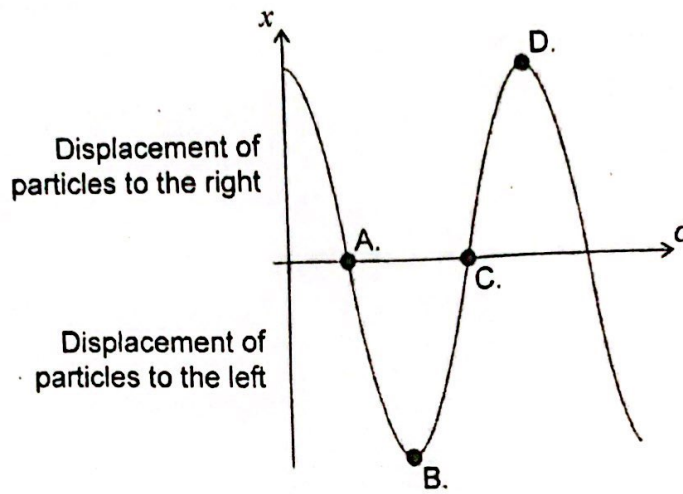
What other frequency is possible for a standing wave in this pipe?

- A. 25 Hz
- B. 50 Hz
- C. 75 Hz
- D. 300 Hz

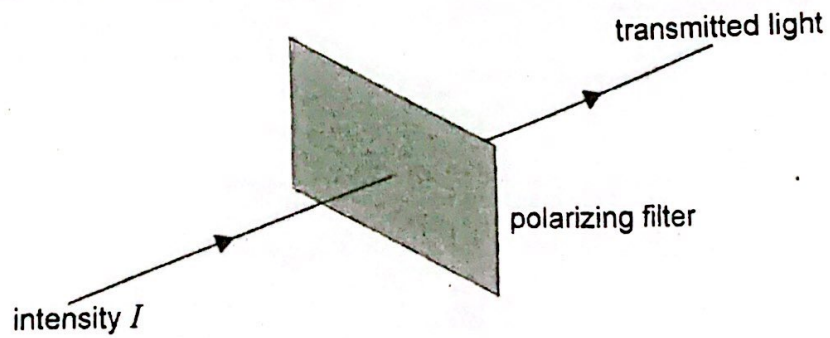


12. A longitudinal wave is travelling through a medium. The variation with distance  $d$  of the displacement  $x$  of the particles in the medium at time  $t$  is shown.

Which point is at the centre of a compression?



13. Unpolarized light of intensity  $I$  and amplitude  $A$  passes through a polarizing filter.



What is the amplitude of the light transmitted by the polarizing filter?

- A.  $\frac{A^2}{2}$
- B.  $\frac{A}{4}$
- C.  $\frac{A}{2}$
- D.  $\frac{A}{\sqrt{2}}$



14. An electromagnetic wave enters a medium of lower refractive index.

Three statements are made:

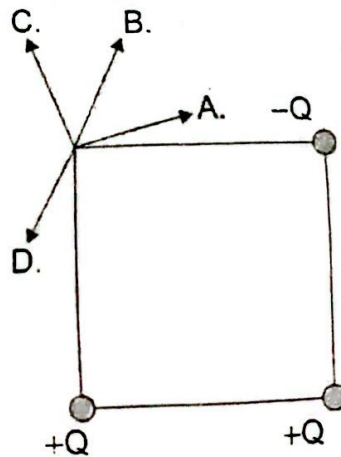
- I. The wavelength of the wave has increased.
- II. The frequency of the wave has decreased.
- III. The speed of the wave has increased.

What is true about the properties of the wave?

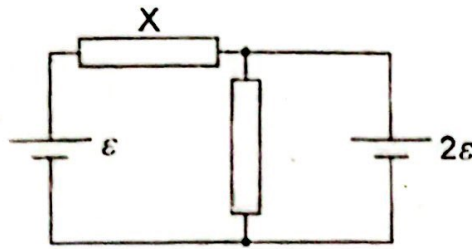
- A. I and II only
- B. I and III only
- C. II and III only
- D. I, II and III

15. Three point charges,  $+Q$ ,  $+Q$  and  $-Q$ , are fixed at the three corners of a square.

What is the direction of the electric field at the fourth corner?



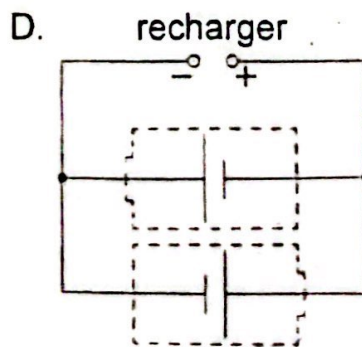
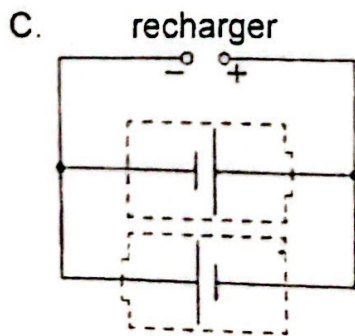
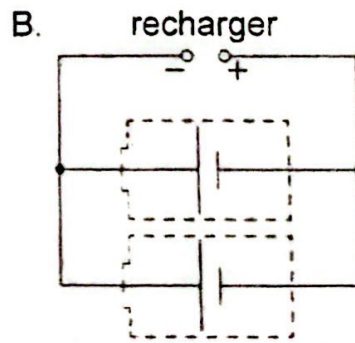
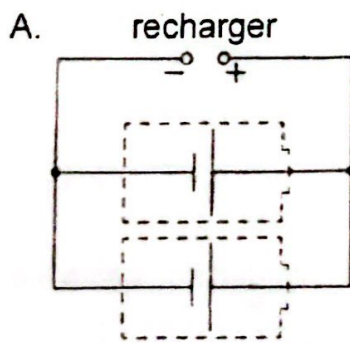
16. Two resistors of equal resistance  $R$  are connected with two cells of emf  $\epsilon$  and  $2\epsilon$ . Both cells have negligible internal resistance.



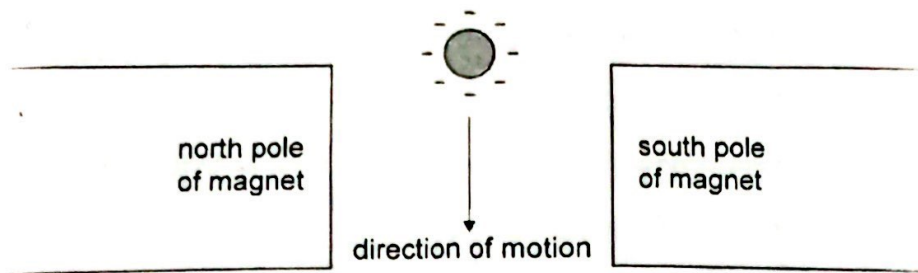
What is the current in the resistor labelled X?

- A.  $\frac{\epsilon}{2R}$
- B.  $\frac{3\epsilon}{2R}$
- C.  $\frac{\epsilon}{R}$
- D.  $\frac{3\epsilon}{R}$

17. Two secondary cells require recharging. Which circuit will recharge both cells?

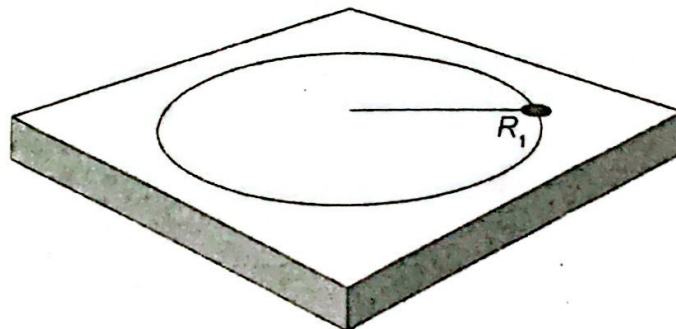


18. A negatively charged sphere is falling through a magnetic field.



What is the direction of the magnetic force acting on the sphere?

- A. To the left of the page
  - B. To the right of the page
  - C. Out of the page
  - D. Into the page
19. A mass on the end of a string is rotating on a frictionless table in circular motion of radius  $R_1$  and undergoes an angular displacement of  $\theta$  in time  $t$ .



The string tension is kept constant, but the angular displacement of the mass is increased to  $2\theta$  in time  $t$ . The radius of the motion changes to  $R_2$ .

What is  $R_2$ ?

- A.  $\frac{R_1}{4}$
- B.  $2R_1$
- C.  $4R_1$
- D.  $R_1 \times R_1$

20. The gravitational field strength at the surface of the Earth is often taken to be  $9.8 \text{ N kg}^{-1}$ .

The use of this value to calculate the weight of an object **above** the surface of the Earth is

- A. a paradigm shift in our understanding of gravity.
- B. an attempt to model gravitational fields.
- C. an outcome from a peer review.
- D. an approximation used for estimation purposes.

21. White light is incident on gas at very low pressure. The light passing through the gas is analysed.

What phenomenon is being investigated?

- A. Absorption spectrum
- B. Emission spectrum
- C. Photoelectric effect
- D. Polarization

22. A student measures the count rate of a radioactive sample with time in a laboratory. The background count in the laboratory is 30 counts per second.

Count rate / counts per second	Time / s
150	0
90	20

What is the time at which the student measures a count rate of 45 counts per second?

- A. 30s
- B. 40s
- C. 60s
- D. 80s

23. Three statements about the binding energy are provided.

- I. The binding energy is the energy required to completely separate the nucleons.
- II. The binding energy is equivalent, in units of energy, to the mass defect when a nucleus is formed from its nucleons.
- III. The binding energy is the energy released when a nucleus is formed from its nucleons.

Which statements are true?

- A. I and II only
  - B. I and III only
  - C. II and III only
  - D. I, II and III
24. The following reaction is proposed for the collision of a proton  $p$  and a neutron  $n$ .



The neutral pion  $\pi^0$  consists of an up quark and an anti-up quark.

Which conservation law does this equation violate?

- A. Baryon number
- B. Charge
- C. Lepton number
- D. Strangeness

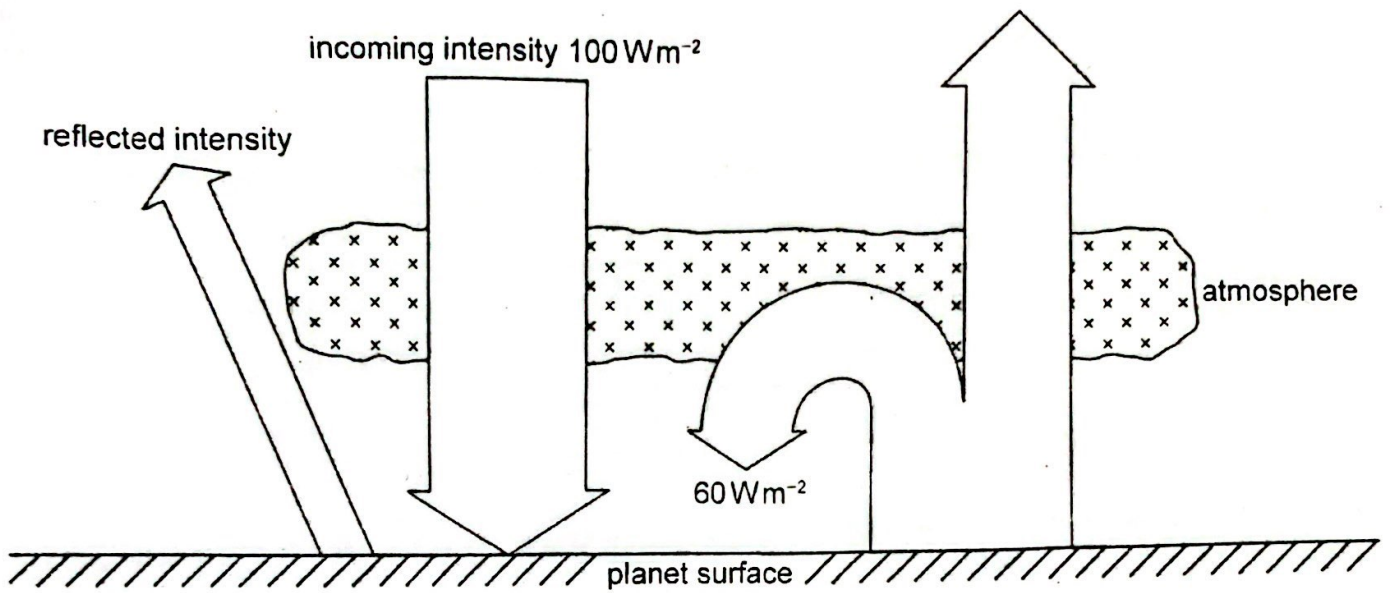
25. Wind generator X has a maximum power output  $P_x$  for a particular wind speed. For the same wind speed, wind generator Y has a maximum power output  $P_y$ .

The blade radius of Y is three times the blade radius of X. Y is twice as efficient as X.

What is  $\frac{P_y}{P_x}$ ?

- A.  $\frac{3}{2}$
  - B.  $\frac{9}{2}$
  - C. 6
  - D. 18
26. What is **not** correct about a photovoltaic cell?
- A. It has an output power that is related to the surface area of the cell.
  - B. It generates an alternating current.
  - C. It absorbs energy over a range of photon frequencies.
  - D. It can be used to store energy in a secondary cell.

27. A planet has an albedo of 0.30. A simplified energy balance for the planet is shown.



What is the intensity radiated by the surface of the planet?

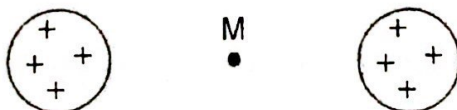
- A.  $70 \text{ Wm}^{-2}$
  - B.  $90 \text{ Wm}^{-2}$
  - C.  $100 \text{ Wm}^{-2}$
  - D.  $130 \text{ Wm}^{-2}$
28. A mass oscillating in simple harmonic motion on the end of a spring has an amplitude  $x_0$  and a total energy  $E_T$ . The mass on the spring is doubled and made to oscillate with the same amplitude  $x_0$ .
- What is the total energy of the oscillating system after the change?
- A.  $E_T$
  - B.  $\sqrt{2}E_T$
  - C.  $2E_T$
  - D.  $4E_T$

29. Monochromatic light is incident on a single slit to form a diffraction pattern on a screen. The width of the single slit is then halved.

What are the change in the width of the central maximum and the change in the maximum intensity of the pattern?

	Change in width of central maximum	Change in maximum intensity of pattern
A.	decrease	increase
B.	decrease	decrease
C.	increase	decrease
D.	increase	increase

30. Two spheres have the same positive charge. A point M is midway between the two spheres.



Along the line joining the spheres, what is true about the electrical field and the electric potential at M?

	Electric field	Electric potential
A.	zero	minimum positive value
B.	maximum	minimum positive value
C.	zero	maximum positive value
D.	maximum	maximum positive value

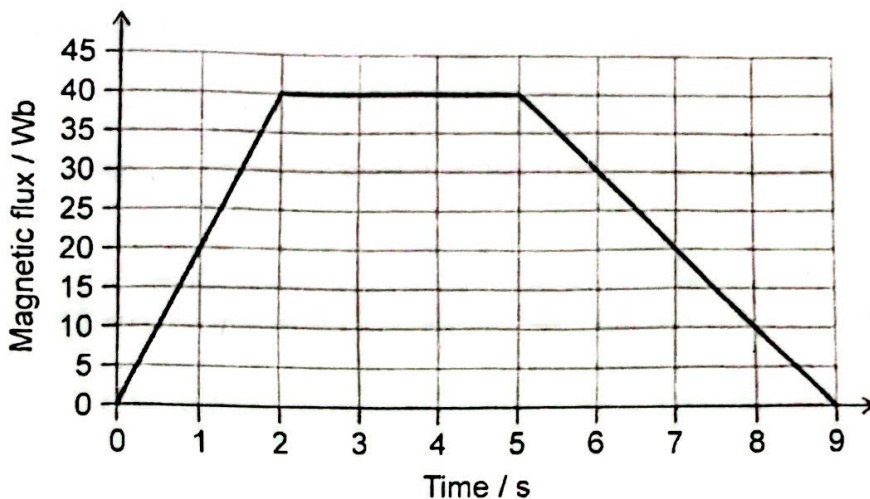
31. The mass of Mars is about ten times that of the Moon. The radius of Mars is about twice that of the Moon.

What is the  $\frac{\text{escape speed from Mars}}{\text{escape speed from Moon}}$ ?

- A.  $\sqrt{5}$
- B.  $2\sqrt{5}$
- C. 5
- D. 25



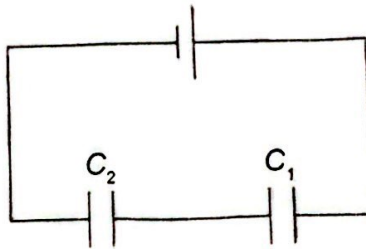
32. A single loop of wire of resistance  $10\Omega$  has its plane perpendicular to a changing magnetic field. The graph shows the variation with time of the magnetic flux linked through the loop of wire.



What is the maximum current in the loop of wire?

- A. 1.0A
  - B. 2.0A
  - C. 4.0A
  - D. 20A
33. An ac generator produces a root mean square (rms) voltage  $V$ . What is the peak output voltage when the frequency is doubled?
- A.  $\frac{2}{\sqrt{2}}V$
  - B.  $\frac{V}{2\sqrt{2}}$
  - C.  $\frac{\sqrt{2}}{2}V$
  - D.  $2\sqrt{2}V$

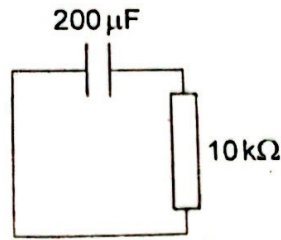
34. Step-up transformers are used in the distribution of electrical energy to
- A. reduce the danger of electrical shock to humans.
  - B. decrease the potential difference between the ends of long-distance transmission lines.
  - C. allow direct current appliances to work in domestic applications.
  - D. decrease the electrical current in long-distance transmission lines.
35. Two capacitors  $C_1$  and  $C_2$  are connected in series to a cell as shown. The capacitance of  $C_1$  is four times the capacitance of  $C_2$ . The charge stored on  $C_1$  is  $q_1$  and the charge stored on  $C_2$  is  $q_2$ .



What is  $\frac{q_1}{q_2}$ ?

- A.  $\frac{1}{4}$
- B.  $\frac{4}{5}$
- C. 1
- D. 4

36. A charged  $200\ \mu\text{F}$  capacitor is placed in series with a  $10\ \text{k}\Omega$  resistor. At time  $t = 0$ , the current is  $I$ .

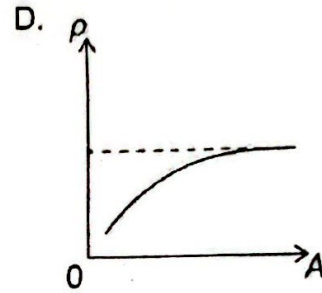
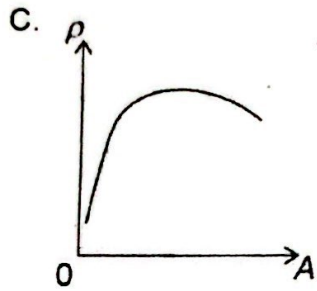
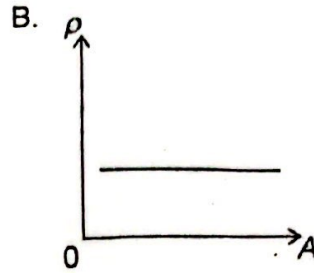
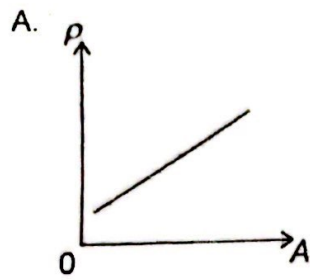


What is the time taken for the current in the resistor to be  $\frac{I}{e^3}$ ?

- A. 2 s
  - B. 3 s
  - C. 6 s
  - D. 8 s
37. Light of frequency  $f$  is incident on a metallic surface of work function  $W$ . Photoelectrons with a maximum kinetic energy  $E_{\text{max}}$  are emitted. The frequency of the incident light is changed to  $2f$ . What is true about the maximum kinetic energy and the work function?

	Maximum kinetic energy	Work function
A.	less than $2E_{\text{max}}$	unchanged
B.	less than $2E_{\text{max}}$	greater than $W$
C.	greater than $2E_{\text{max}}$	unchanged
D.	greater than $2E_{\text{max}}$	greater than $W$

38. What is the variation of nuclear density  $\rho$  with nucleon number  $A$ ?

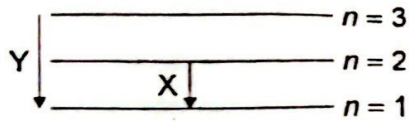


39. The uncertainty in the energy required for pair production is 3 MeV. What is the uncertainty in the lifetime of the pair?

- A.  $10^{-7}$  s
- B.  $10^{-12}$  s
- C.  $10^{-17}$  s
- D.  $10^{-22}$  s

40. Some energy levels for a hydrogen atom are shown.

diagram not to scale



What is the  $\frac{\text{wavelength emitted in transition X}}{\text{wavelength emitted in transition Y}}$ ?

- A.  $\frac{1}{2}$
- B.  $\frac{27}{32}$
- C.  $\frac{32}{27}$
- D. 2