Diploma Programme
Programme du diplôme
Programa del Diploma

Physics
Higher level
Paper 1

Friday 6 May 2016 (morning)

1 hour

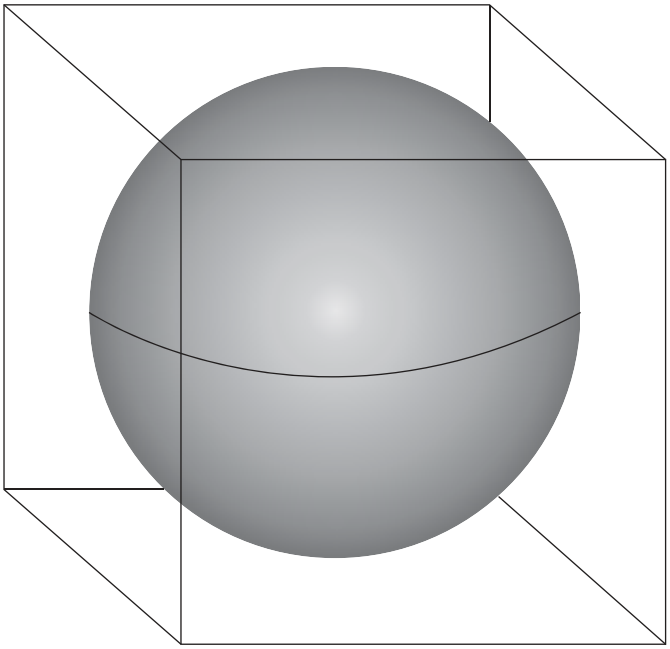
Instructions to candidates

- 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]**.

2216 – 6501

23 pages

1. A sphere fits inside a cube.



The length of the cube and the diameter of the sphere are 10.0 ± 0.2 cm.

What is the ratio $\frac{\text{percentage uncertainty of the volume of the sphere}}{\text{percentage uncertainty of the volume of the cube}}$?

A. $\frac{3}{4\pi}$

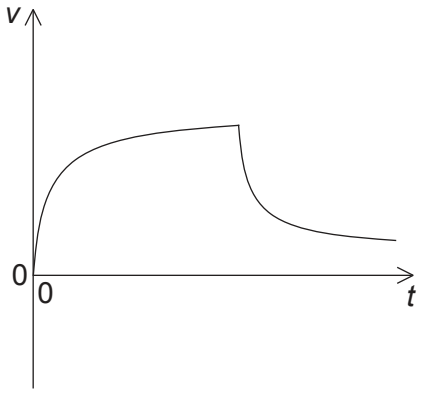
B. 1

C. 2

D. 8

2. An aircraft is moving horizontally. A parachutist leaves the aircraft and a few seconds later opens her parachute. Which graph shows the variation of the vertical speed *v* with time *t* for the parachutist from the time she leaves the aircraft until just before landing?

A.



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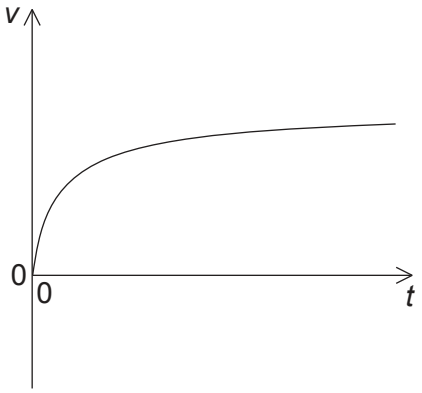

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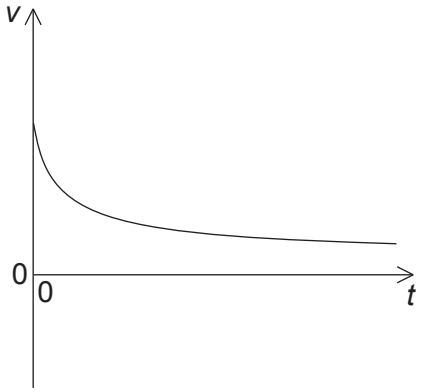

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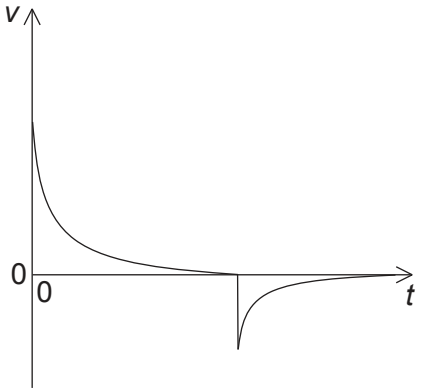


3. An object of mass *m* rests on a horizontal plane. The angle θ that the plane makes with the horizontal is slowly increased from zero. When $\theta = \theta_0$, the object begins to slide. What are the coefficient of static friction μ_s and the normal reaction force *N* of the plane at $\theta = \theta_0$?

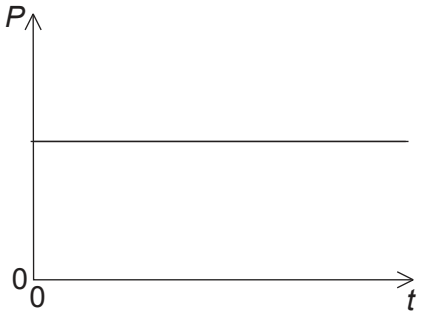
	μ_s	*N*
A.	$\sin \theta_0$	$mg \cos \theta_0$
B.	$\tan \theta_0$	$mg \sin \theta_0$
C.	$\sin \theta_0$	$mg \sin \theta_0$
D.	$\tan \theta_0$	$mg \cos \theta_0$

4. A ball with mass m moves horizontally with speed u. The ball hits a vertical wall and rebounds in the opposite direction with speed $v < u$. The duration of the collision is T. What are the magnitude of the average force exerted by the wall on the ball and the loss of kinetic energy of the ball?

	Average force	Loss of kinetic energy
A.	$\frac{m(u+v)}{T}$	$\frac{m(u^2-v^2)}{2}$
B.	$\frac{m(u+v)}{T}$	$\frac{m(u-v)^2}{2}$
C.	$\frac{m(u-v)}{T}$	$\frac{m(u^2-v^2)}{2}$
D.	$\frac{m(u-v)}{T}$	$\frac{m(u-v)^2}{2}$

5. A train on a straight horizontal track moves from rest at constant acceleration. The horizontal forces on the train are the engine force and a resistive force which increases with speed. Which graph represents the variation with time t of the power P developed by the engine?

A.



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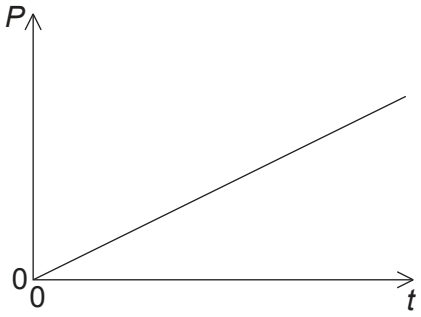

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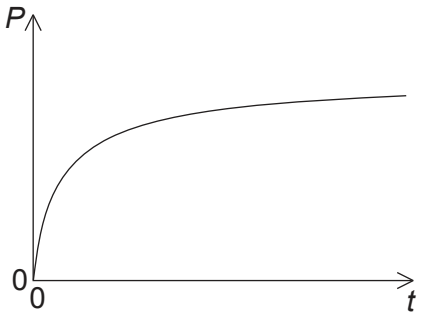

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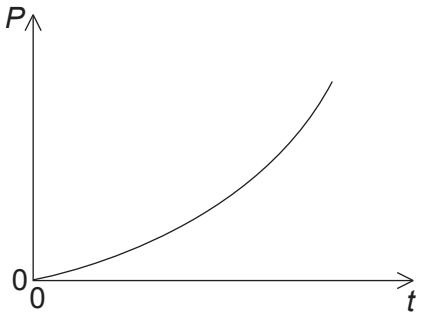
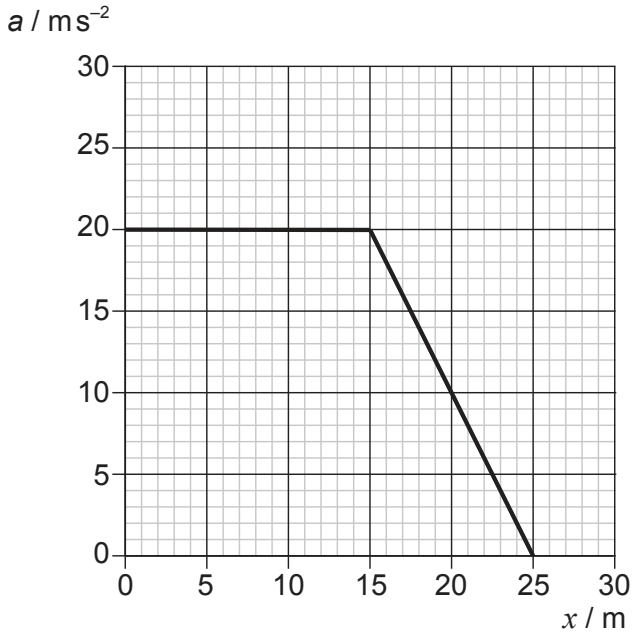


6. The graph shows how the acceleration *a* of an object varies with distance travelled x.



The mass of the object is 3.0 kg. What is the total work done on the object?

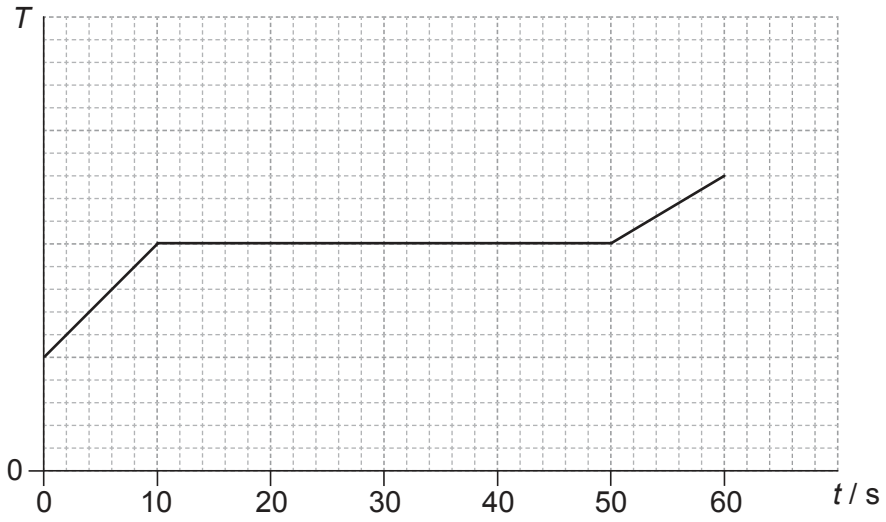
A. 300 J

B. 400 J

C. 1200 J

D. 1500 J

7. A container with 0.60 kg of a liquid substance is placed on a heater at time $t = 0$. The specific latent heat of vaporization of the substance is 200 kJ kg^{-1}. The graph shows the variation of the temperature T of the substance with time t.



What is the power of the heater?

A. 1200 W

B. 3000 W

C. 4800 W

D. 13 300 W

8. Under what conditions of density and pressure is a real gas best described by the equation of state for an ideal gas?

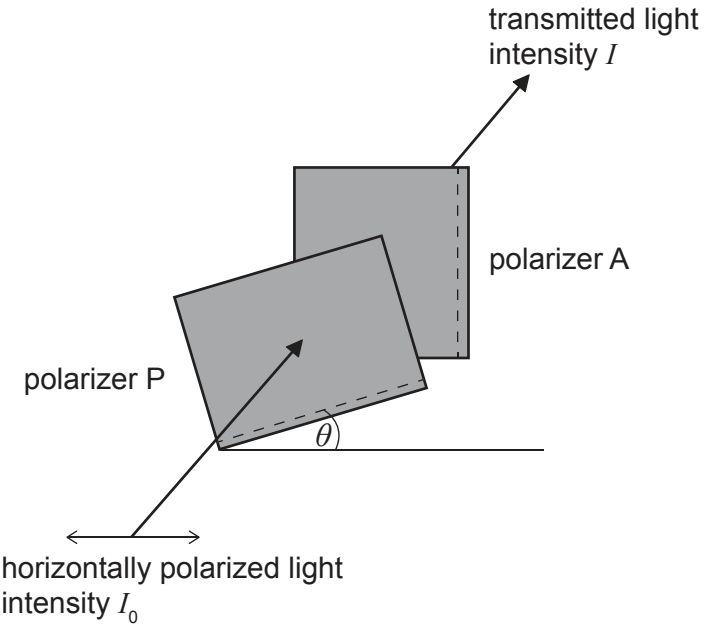
A. Low density and low pressure

B. Low density and high pressure

C. High density and low pressure

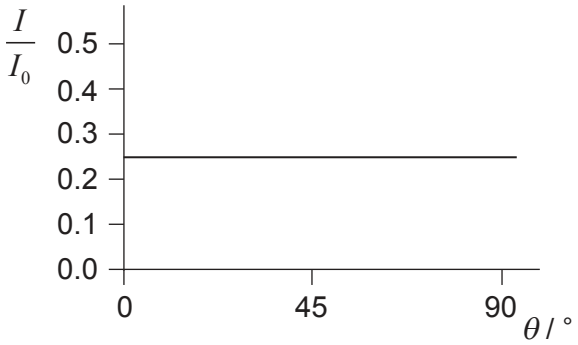
D. High density and high pressure

9. Horizontally polarized light of intensity I_0 enters a polarizer P whose polarization axis makes an angle of θ degrees with the horizontal. Light from P is then incident on a polarizer A with fixed vertical polarization axis.



The angle θ is varied from 0 to 90 degrees. Which of the following represents the variation with θ of the intensity I of the light transmitted through A?

A.



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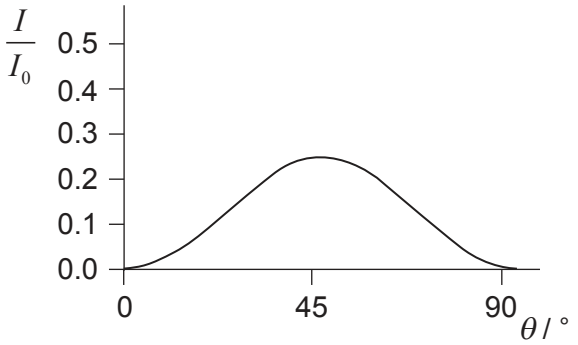

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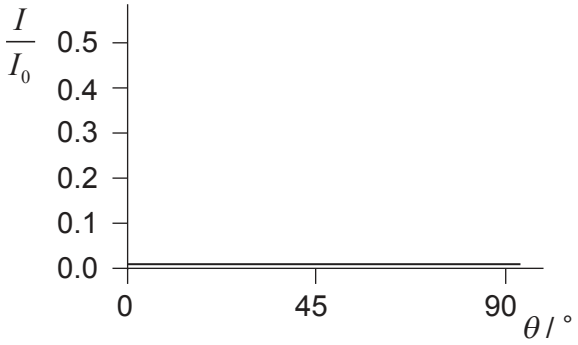

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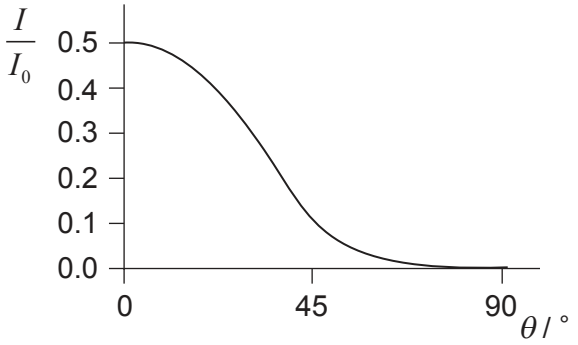


10. A pipe of length L has two open ends. Another pipe of length L' has one open end and one closed end.

The frequency of the first harmonic of both pipes is the same. What is $\frac{L'}{L}$?

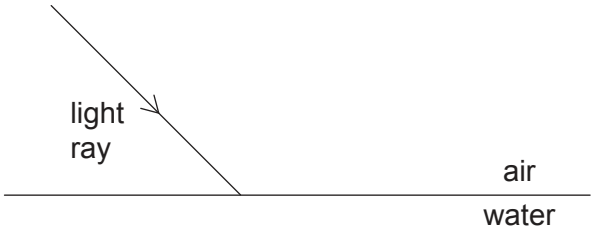
A. 2

B. $\frac{3}{2}$

C. 1

D. $\frac{1}{2}$

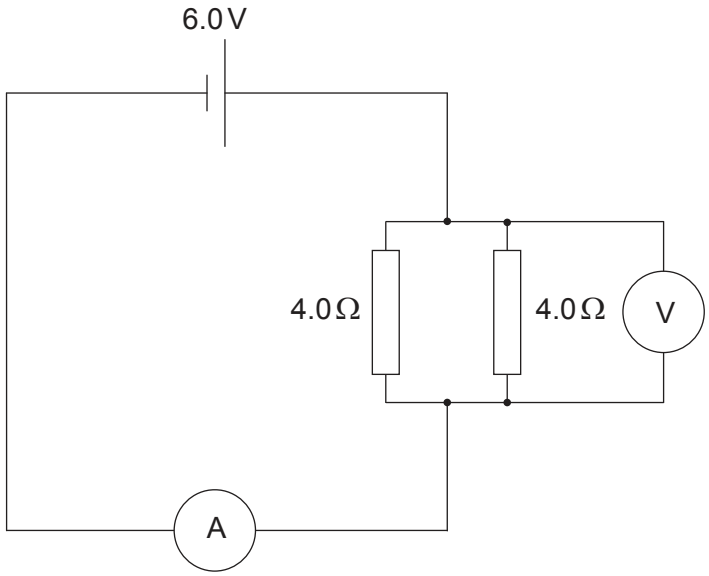
11. A light ray passes from air to water as shown.



What are the change in the wavelength of the light wave and the change in the angle the ray makes with the normal to the surface?

	Wavelength	Angle with normal
A.	increases	increases
B.	increases	decreases
C.	decreases	increases
D.	decreases	decreases

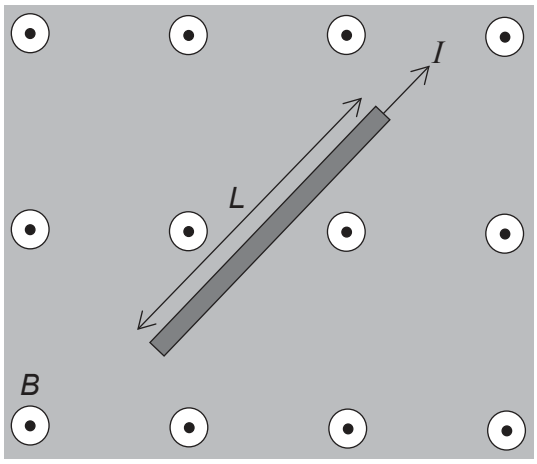
12. A circuit consists of a cell of electromotive force (emf) 6.0 V and negligible internal resistance connected to two resistors of 4.0 Ω.



The ammeter has resistance equal to 1.0 Ω and the voltmeter is ideal. What are the readings of the ammeter and the voltmeter?

	Ammeter	Voltmeter
A.	2.0 A	3.0 V
B.	3.0 A	3.0 V
C.	2.0 A	4.0 V
D.	3.0 A	4.0 V

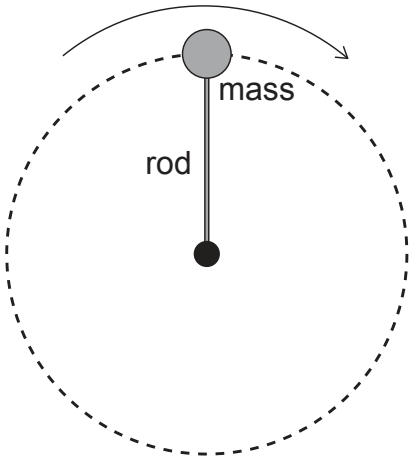
13. A wire carrying a current I is placed in a region of uniform magnetic field B, as shown in the diagram.



The direction of the field B is out of the page and the length of the wire is L. What is correct about the direction and magnitude of the force acting on the wire?

	Direction	Magnitude
A.	↘	equal to BIL
B.	↘	smaller than BIL
C.	↗	equal to BIL
D.	↗	smaller than BIL

14. A mass connected to one end of a rigid rod rotates at constant speed in a vertical plane about the other end of the rod.



The force exerted by the rod on the mass is

A. zero everywhere.

B. constant in magnitude.

C. always directed towards the centre.

D. a minimum at the top of the circular path.

15. A simple model of an atom has five energy levels. What is the maximum number of different frequencies in the emission spectrum of that atom?

A. 4

B. 6

C. 10

D. 25

16. Which of the following lists three fundamental forces in increasing order of strength?

A. electromagnetic, gravity, strong nuclear

B. weak nuclear, gravity, strong nuclear

C. gravity, weak nuclear, electromagnetic

D. electromagnetic, strong nuclear, gravity

17. Patterns in graphs help scientists make predictions. What can be deduced from a graph of neutron number versus proton number for all stable nuclides?

A. The short-range nature of the strong nuclear force

B. The increase of the binding energy per nucleon with proton number

C. The existence of quarks and leptons

D. The existence of alpha decay

18. A solar panel has surface area $0.40\,m^2$ and efficiency 50 %. The average intensity of radiation reaching the surface of the panel is $0.25\,kW\,m^{-2}$. What is the average power output from an array of 10 of these solar panels?

A. 0.5 W

B. 5 W

C. 50 W

D. 500 W

19. What is the correct order of energy transformations in a coal power station?

A. thermal $\rightarrow$ chemical $\rightarrow$ kinetic $\rightarrow$ electrical

B. chemical $\rightarrow$ thermal $\rightarrow$ kinetic $\rightarrow$ electrical

C. chemical $\rightarrow$ kinetic $\rightarrow$ thermal $\rightarrow$ electrical

D. kinetic $\rightarrow$ chemical $\rightarrow$ electrical $\rightarrow$ thermal

20. A black body of surface $1.0\,m^2$ emits electromagnetic radiation of peak wavelength $2.90 \times 10^{-6}\,m$. Which of the following statements about the body are correct?

I. The temperature of the body is 1000 K.

II. The energy radiated by the body in one second is $5.7 \times 10^4\,J$.

III. The body is a perfect absorber of electromagnetic radiation.

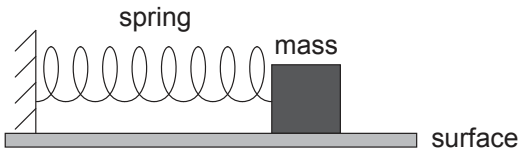
A. I and II only

B. I and III only

C. II and III only

D. I, II and III

21. A mass is connected to a spring on a frictionless horizontal surface as shown.



The spring is extended beyond its equilibrium length and the mass executes simple harmonic motion (SHM). Which of the following is independent of the initial displacement of the spring?

A. The angular frequency of the oscillation

B. The total energy of the mass

C. The average speed of the mass

D. The maximum kinetic energy of the mass

22. A single-slit diffraction experiment is performed using light of different colours. The width of the central peak in the diffraction pattern is measured for each colour. What is the order of the colours that corresponds to increasing widths of the central peak?

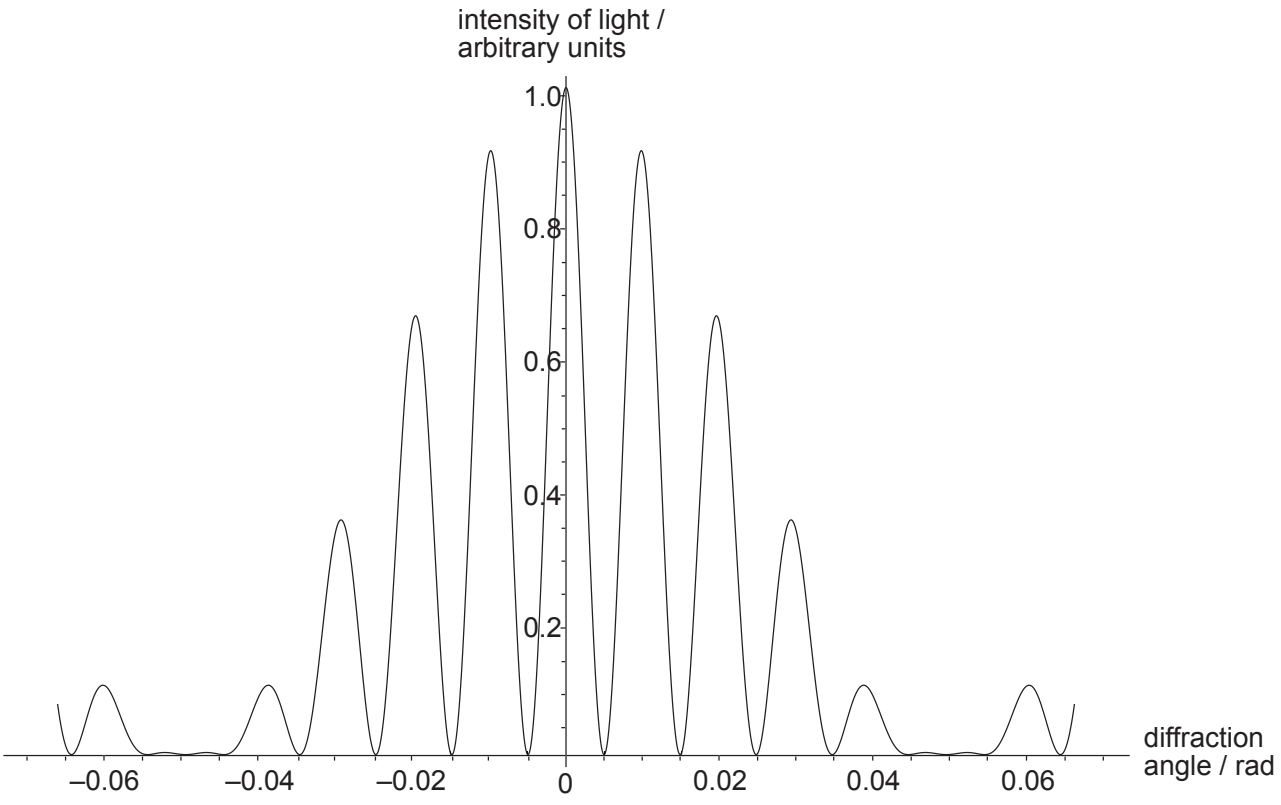
A. red, green, blue

B. red, blue, green

C. blue, green, red

D. green, blue, red

23. In a double-slit interference experiment, the following intensity pattern is observed for light of wavelength λ.



The distance between the slits is *d*. What can be deduced about the value of the ratio $\frac{\lambda}{d}$ and the effect of single-slit diffraction in this experiment?

	$\frac{\lambda}{d}$	**Single-slit diffraction**
A.	100	non-negligible
B.	0.01	non-negligible
C.	100	negligible
D.	0.01	negligible

24. A simple pendulum has mass *M* and length l. The period of oscillation of the pendulum is *T*. What is the period of oscillation of a pendulum with mass 4*M* and length 0.25*l*?

A. 0.5*T*

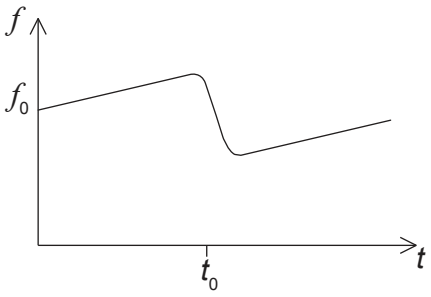
B. *T*

C. 2*T*

D. 4*T*

25. A train moves at constant speed whilst emitting a sound wave of frequency f_0. At $t = t_0$ the train passes through a station. Which graph shows the variation with time *t* of the frequency f of the sound wave as measured by an observer standing on the station platform?

A.



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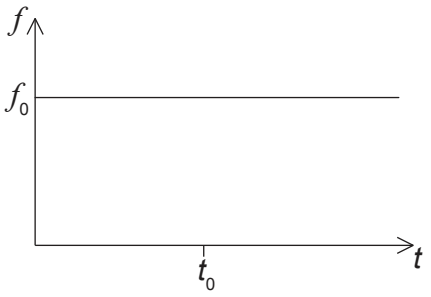

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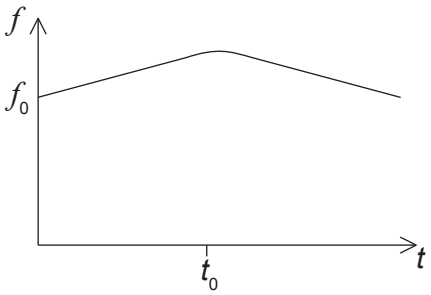

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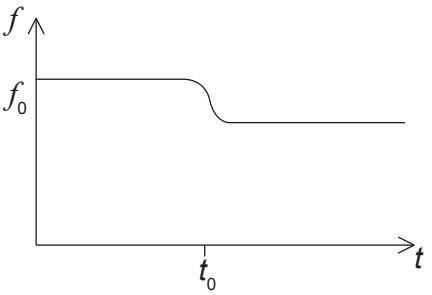
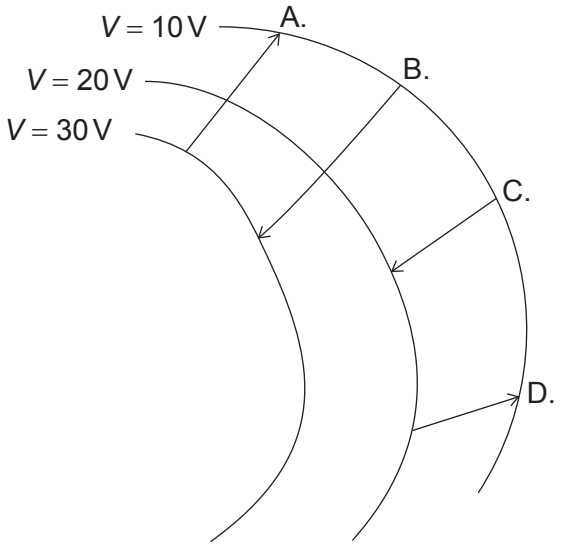


26. A negative charge moves in an electric field. Equipotential lines for the field and four possible paths of the charge are shown. Which path corresponds to the largest work done on the charge by the field?



27. In an experiment, oil droplets of mass m and charge q are dropped into the region between two horizontal parallel plates. The electric field E between the plates can be adjusted. Air resistance is negligible. Which is correct when the droplets fall vertically at constant velocity?

A. $E = 0$

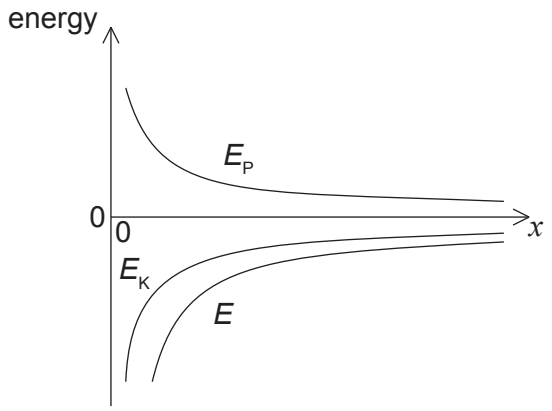
B. $E < \frac{mg}{q}$

C. $E = \frac{mg}{q}$

D. $E > \frac{mg}{q}$

28. A satellite orbits a planet. Which graph shows how the kinetic energy E_K, the potential energy E_P and the total energy E of the satellite vary with distance x from the centre of the planet?

A.



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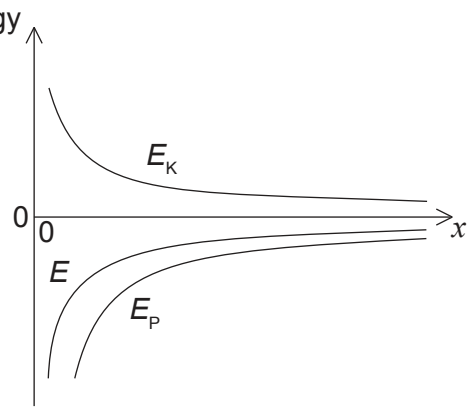

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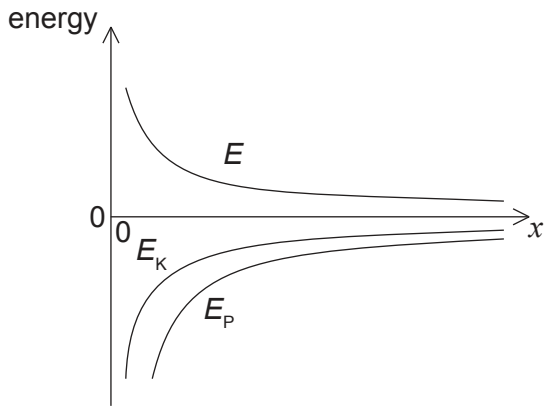

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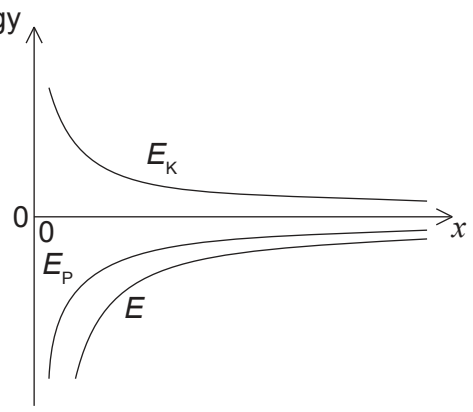
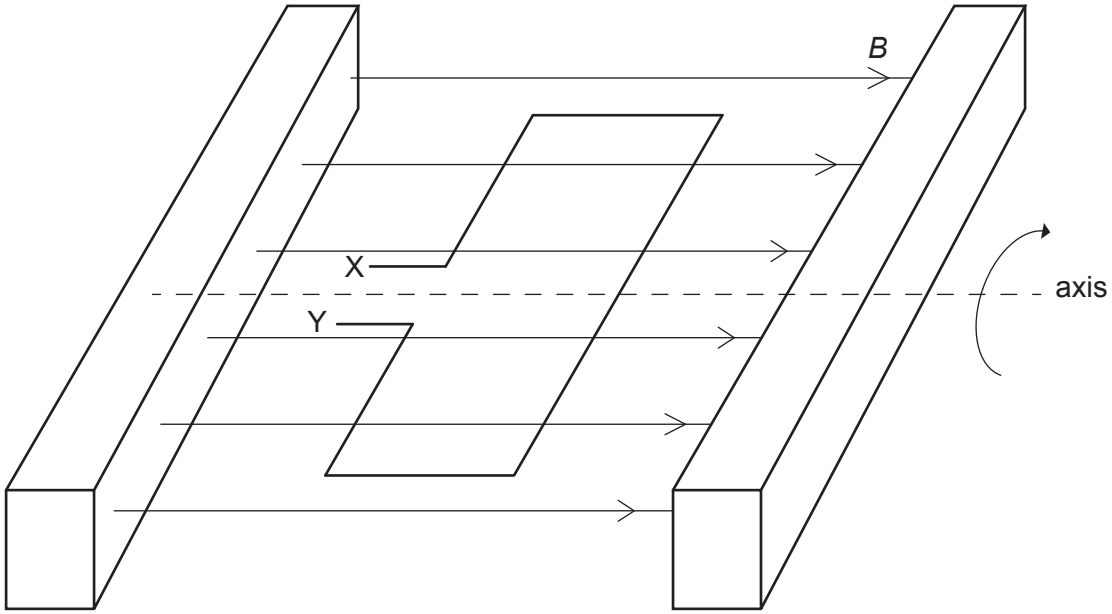


29. A coil of area A is placed in a region of uniform horizontal magnetic field B. At $t = 0$, the coil starts to rotate with constant angular speed ω about a horizontal axis.



What is the emf between X and Y?

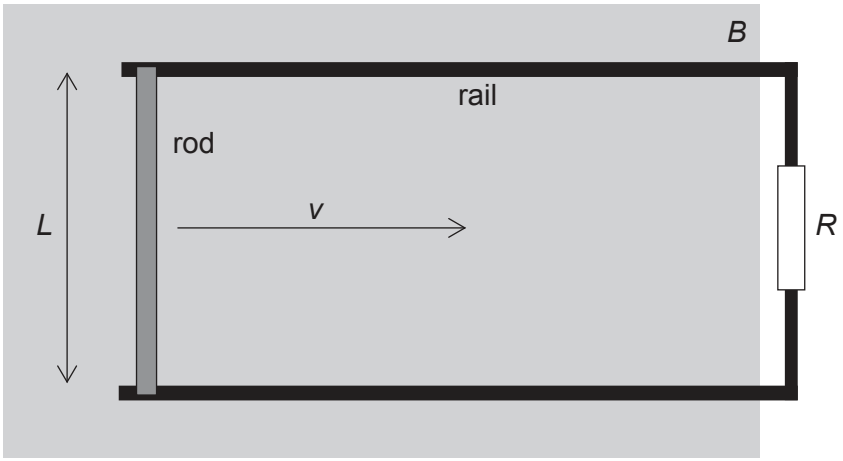
A. zero

B. $\omega AB \sin \omega t$

C. $AB \cos \omega t$

D. $-\omega AB \sin \omega t$

30. The diagram shows a conducting rod of length L being moved in a region of uniform magnetic field B. The field is directed at right angles to the plane of the paper. The rod slides on conducting rails at a constant speed v. A resistor of resistance R connects the rails.



What is the power required to move the rod?

A. zero

B. $\frac{vBL}{R}$

C. $\frac{v^2B^2L^2}{R}$

D. $\frac{v^2B^2L^2}{R^2}$

31. An alternating current (ac) power supply generates an emf with peak amplitude V_0 and delivers an average power $\bar{P}$. What is the root mean square (rms) current delivered by the supply?

A. $\frac{\bar{P}}{2V_0}$

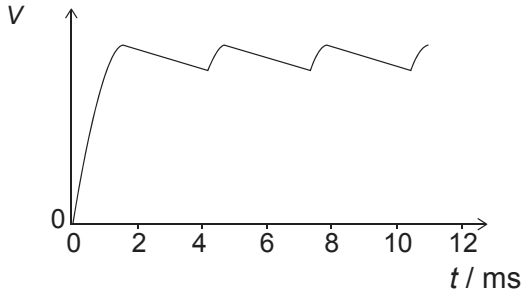
B. $\frac{\bar{P}}{\sqrt{2}V_0}$

C. $\frac{\sqrt{2}\,\bar{P}}{V_0}$

D. $\frac{2\bar{P}}{V_0}$

32. A full-wave diode rectification circuit is modified with the addition of a capacitor in parallel with the load resistor. The circuit is used to rectify a sinusoidal signal of period 6.3 ms. Which graph shows how the potential difference *V* across the load varies with time?

A.



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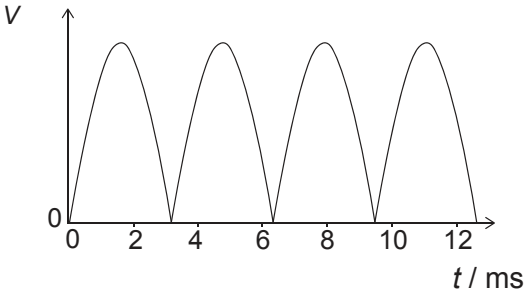

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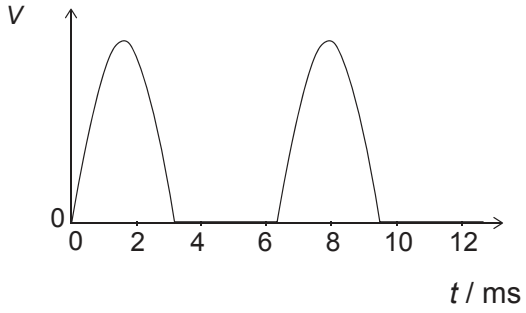

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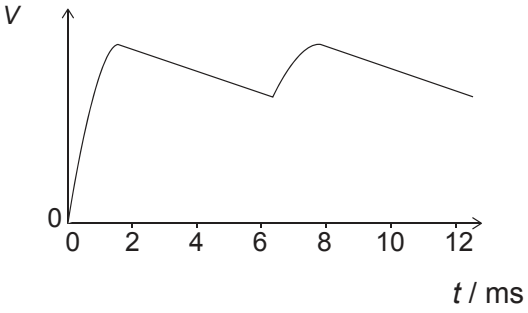
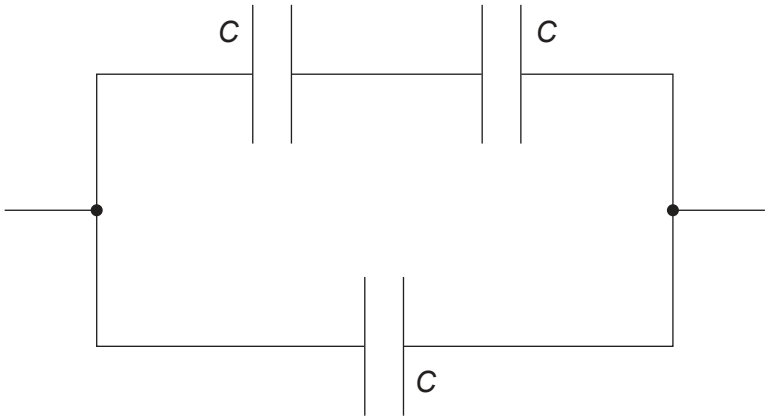


33. A parallel-plate capacitor is connected to a cell of constant emf. The capacitor plates are then moved further apart without disconnecting the cell. What are the changes in the magnitude of the electric field between the plates and in the capacitance of the capacitor?

	Magnitude of the electric field	**Capacitance**
A.	increases	increases
B.	increases	decreases
C.	decreases	increases
D.	decreases	decreases

34. Three identical capacitors, each of capacitance C, are connected as shown.



What is the total capacitance of the combination?

A. $\frac{2}{3}C$

B. C

C. $\frac{3}{2}C$

D. $3C$

35. Which of the following experiments provides evidence for the existence of matter waves?

A. Scattering of alpha particles

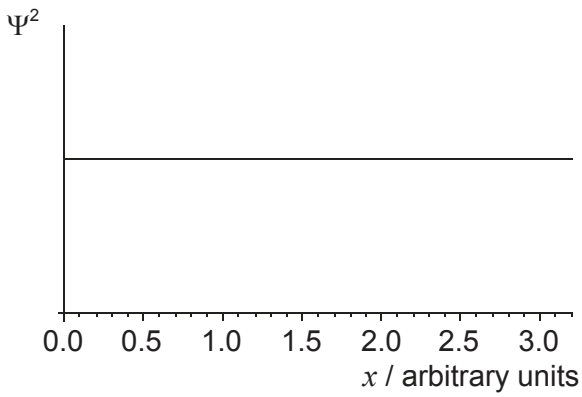
B. Electron diffraction

C. Gamma decay

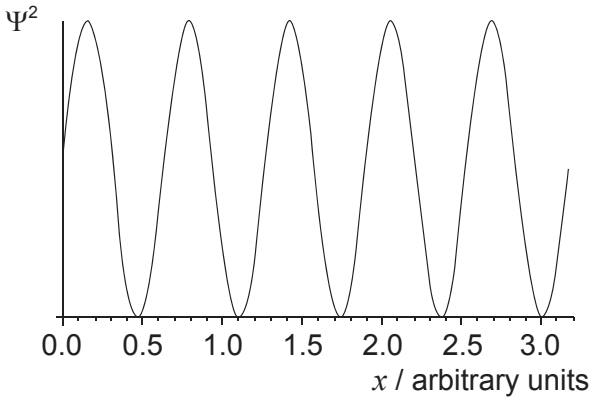
D. Photoelectric effect

36. The graphs show the variation with distance x of the square of the amplitude Ψ^2 of the wave function of a particle. Which graph corresponds to a particle with the largest uncertainty in momentum?

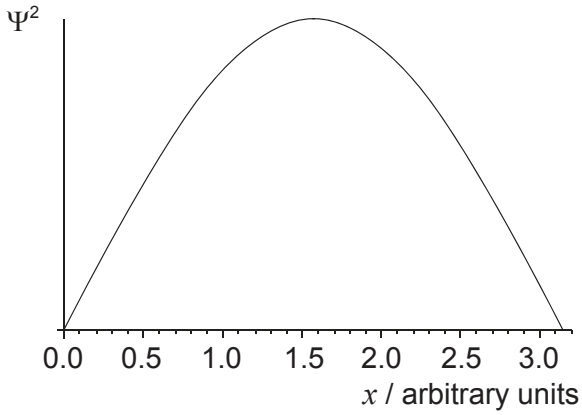
A.



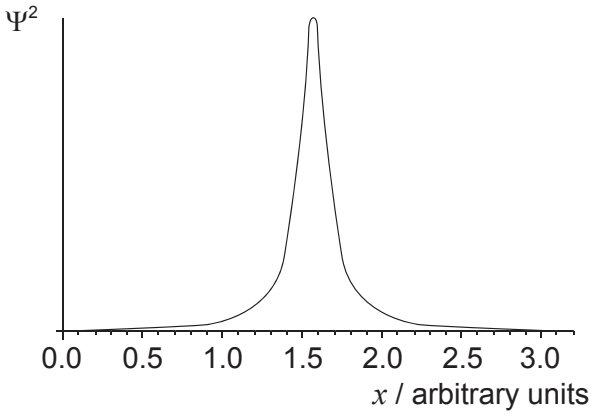
B.



C.



D.



37. Deviations from Rutherford scattering are detected in experiments carried out at high energies. What can be deduced from these deviations?

A. The impact parameter of the collision

B. The existence of a force different from electrostatic repulsion

C. The size of alpha particles

D. The electric field inside the nucleus

38. Different metal surfaces are investigated in an experiment on the photoelectric effect. A graph of the variation of the maximum kinetic energy of photoelectrons with the frequency of the incident light is drawn for each metal. Which statement is correct?

A. All graphs have the same intercept on the frequency axis.

B. The work function is the same for all surfaces.

C. All graphs have the same slope.

D. The threshold frequency is the same for all surfaces.

39. A pure sample of mass m of a radioactive substance with half-life $T_{\frac{1}{2}}$ has an initial activity A_0.

What are the half-life and the initial activity of a pure sample of mass $2m$ of the same radioactive substance?

	Half-life	Initial activity
A.	$T_{\frac{1}{2}}$	A_0
B.	$T_{\frac{1}{2}}$	$2A_0$
C.	$2T_{\frac{1}{2}}$	A_0
D.	$2T_{\frac{1}{2}}$	$2A_0$

40. Nuclear density

A. is constant because the volume of a nucleus is proportional to its nucleon number.

B. is constant because the volume of a nucleus is proportional to its proton number.

C. depends on the nucleon number of the nucleus.

D. depends on the proton number of the nucleus.