

Physics
Higher level
Paper 1

Thursday 10 May 2018 (afternoon)

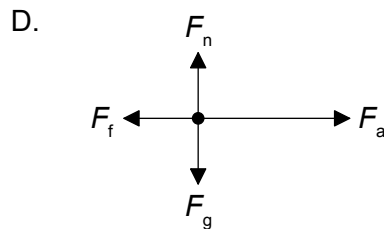
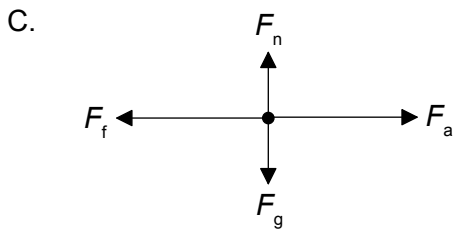
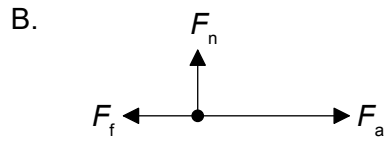
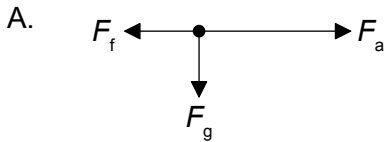
1 hour

Instructions to candidates

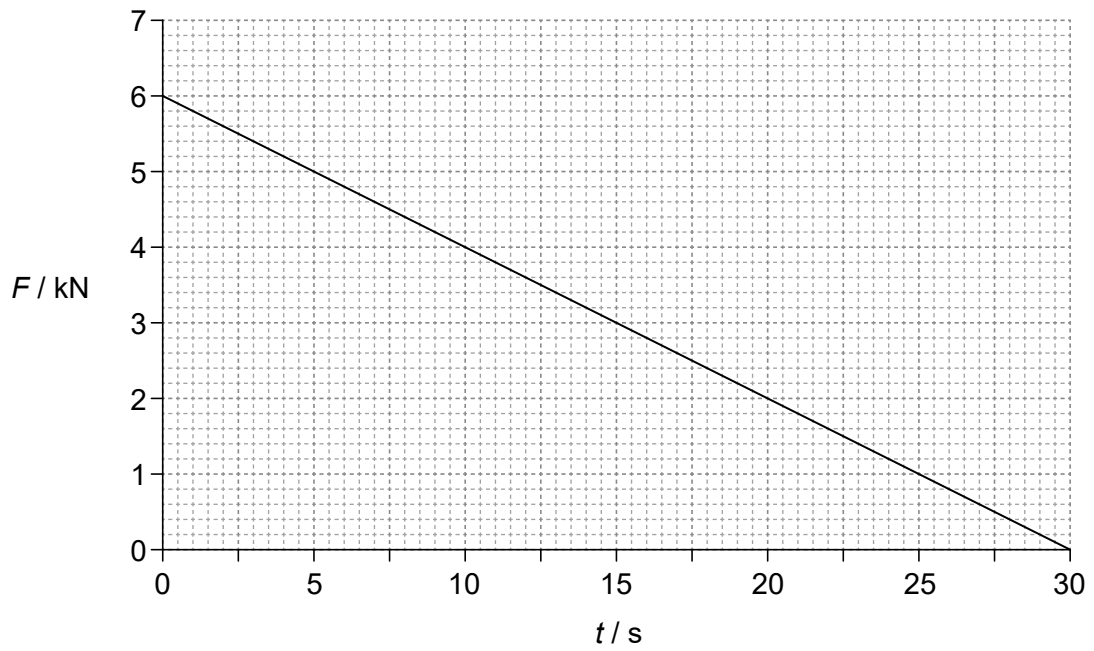
- Do not open this examination paper until instructed to do so.
- Answer all the questions.
- For each question, choose the answer you consider to be the best and indicate your choice on the answer sheet provided.
- A clean copy of the **physics data booklet** is required for this paper.
- The maximum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

1. What is the best estimate for the diameter of a helium nucleus?
- A. 10^{-21} m
 - B. 10^{-18} m
 - C. 10^{-15} m
 - D. 10^{-10} m
2. A motor of input power 160 W raises a mass of 8.0 kg vertically at a constant speed of 0.50 m s^{-1} . What is the efficiency of the system?
- A. 0.63 %
 - B. 25 %
 - C. 50 %
 - D. 100 %

3. A box is accelerated to the right across rough ground by a horizontal force F_a . The force of friction is F_f . The weight of the box is F_g and the normal reaction is F_n . Which is the free-body diagram for this situation?



4. The graph shows the variation with time t of the force F acting on an object of mass 15000 kg. The object is at rest at $t=0$.

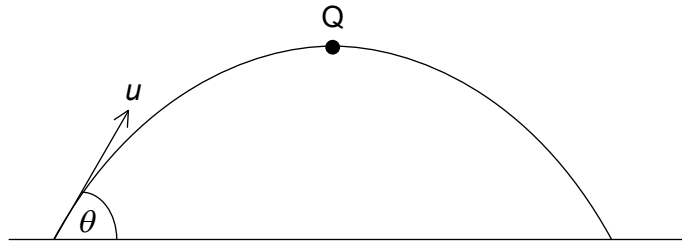


What is the speed of the object when $t=30 \text{ s}$?

- A. 0.18 m s^{-1}
- B. 6 m s^{-1}
- C. 12 m s^{-1}
- D. 180 m s^{-1}

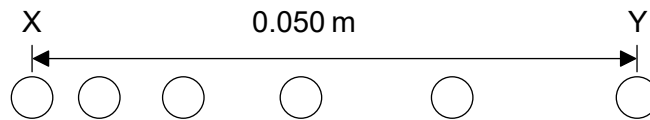
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5. A ball of mass m is thrown with an initial speed of u at an angle θ to the horizontal as shown. Q is the highest point of the motion. Air resistance is negligible.



What is the momentum of the ball at Q?

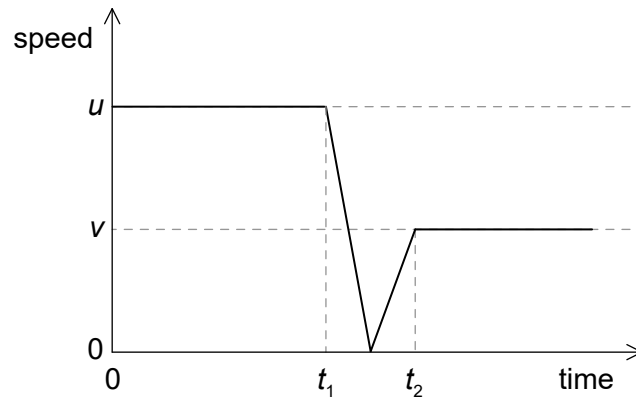
- A. zero
 - B. $mu \cos \theta$
 - C. mu
 - D. $mu \sin \theta$
6. A ball starts from rest and moves horizontally. Six positions of the ball are shown at time intervals of 1.0 ms. The horizontal distance between X, the initial position, and Y, the final position, is 0.050 m.



What is the average acceleration of the ball between X and Y?

- A. 2000 m s^{-2}
- B. 4000 m s^{-2}
- C. 5000 m s^{-2}
- D. 8000 m s^{-2}

7. A ball of mass m collides with a vertical wall with an initial horizontal speed u and rebounds with a horizontal speed v . The graph shows the variation of the speed of the ball with time.

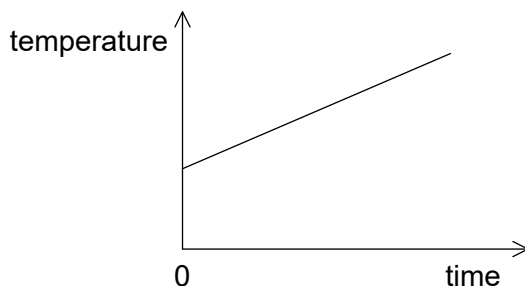


What is the magnitude of the mean net force on the ball during the collision?

- A. $\frac{m(u-v)}{(t_2+t_1)}$
- B. $\frac{m(u-v)}{(t_2-t_1)}$
- C. $\frac{m(u+v)}{(t_2+t_1)}$
- D. $\frac{m(u+v)}{(t_2-t_1)}$

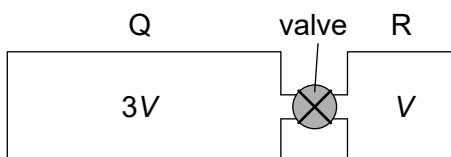
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8. The graph shows how the temperature of a liquid varies with time when energy is supplied to the liquid at a constant rate P . The gradient of the graph is K and the liquid has a specific heat capacity c .



What is the mass of the liquid?

- A. $\frac{P}{cK}$
- B. $\frac{PK}{c}$
- C. $\frac{Pc}{K}$
- D. $\frac{cK}{P}$
9. Q and R are two rigid containers of volume $3V$ and V respectively containing molecules of the same ideal gas initially at the same temperature. The gas pressures in Q and R are p and $3p$ respectively. The containers are connected through a valve of negligible volume that is initially closed.



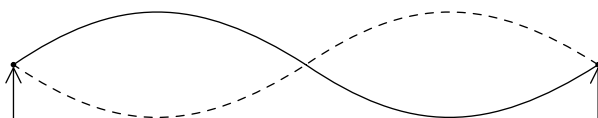
The valve is opened in such a way that the temperature of the gases does not change. What is the change of pressure in Q?

- A. $+p$
- B. $\frac{+p}{2}$
- C. $\frac{-p}{2}$
- D. $-p$

10. Two sound waves from a point source on the ground travel through the ground to a detector. The speed of one wave is 7.5 km s^{-1} , the speed of the other wave is 5.0 km s^{-1} . The waves arrive at the detector 15 s apart. What is the distance from the point source to the detector?
- A. 38 km
 - B. 45 km
 - C. 113 km
 - D. 225 km
11. What is true about the acceleration of a particle that is oscillating with simple harmonic motion (SHM)?
- A. It is in the opposite direction to its velocity
 - B. It is decreasing when the potential energy is increasing
 - C. It is proportional to the frequency of the oscillation
 - D. It is at a minimum when the velocity is at a maximum
12. What are the changes in the speed and in the wavelength of monochromatic light when the light passes from water to air?

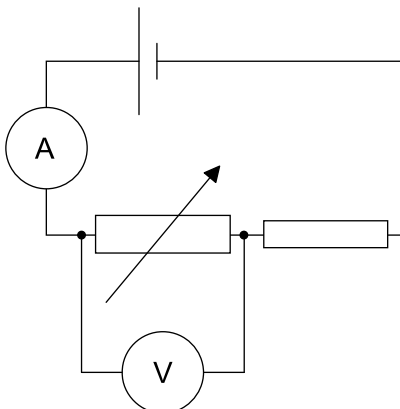
	Change in speed	Change in wavelength
A.	increases	increases
B.	increases	decreases
C.	decreases	increases
D.	decreases	decreases

13. A string stretched between two fixed points sounds its second harmonic at frequency f .



Which expression, where n is an integer, gives the frequencies of harmonics that have a node at the centre of the string?

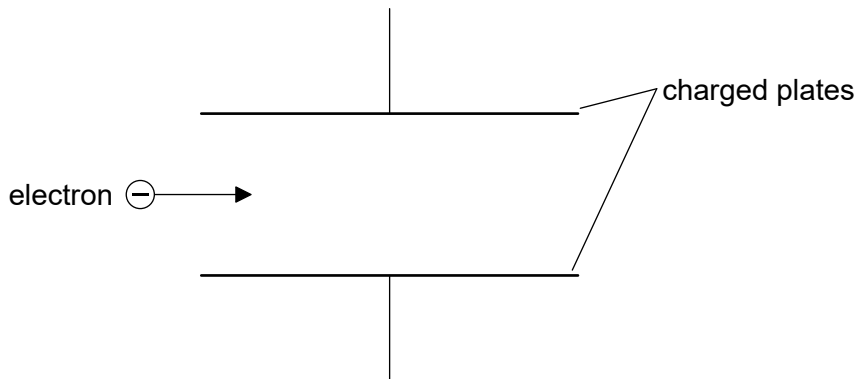
- A. $\frac{n+1}{2}f$
 - B. nf
 - C. $2nf$
 - D. $(2n+1)f$
14. A cell with negligible internal resistance is connected as shown. The ammeter and the voltmeter are both ideal.



What changes occur in the ammeter reading and in the voltmeter reading when the resistance of the variable resistor is increased?

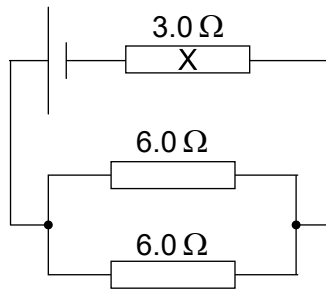
	Change in ammeter reading	Change in voltmeter reading
A.	increases	increases
B.	increases	decreases
C.	decreases	increases
D.	decreases	decreases

15. An electron enters the region between two charged parallel plates initially moving parallel to the plates.



The electromagnetic force acting on the electron

- A. causes the electron to decrease its horizontal speed.
 - B. causes the electron to increase its horizontal speed.
 - C. is parallel to the field lines and in the opposite direction to them.
 - D. is perpendicular to the field direction.
16. A cell of emf 6.0 V and negligible internal resistance is connected to three resistors as shown. The resistors have resistance of 3.0 Ω and 6.0 Ω as shown.



What is the current in resistor X?

- A. 0.40 A
- B. 0.50 A
- C. 1.0 A
- D. 2.0 A

Turn over

17. An object of mass m moves in a horizontal circle of radius r with a constant speed v . What is the rate at which work is done by the centripetal force?

A. $\frac{mv^3}{r}$

B. $\frac{mv^3}{2\pi r}$

C. $\frac{mv^3}{4\pi r}$

D. zero

18. A detector, placed close to a radioactive source, detects an activity of 260 Bq. The average background activity at this location is 20 Bq. The radioactive nuclide has a half-life of 9 hours. What activity is detected after 36 hours?

A. 15 Bq

B. 16 Bq

C. 20 Bq

D. 35 Bq

19. Element X decays through a series of alpha (α) and beta minus (β^-) emissions. Which series of emissions results in an isotope of X?

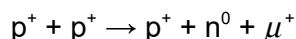
A. 1α and $2\beta^-$

B. 1α and $4\beta^-$

C. 2α and $2\beta^-$

D. 2α and $3\beta^-$

20. Identify the conservation law violated in the proposed reaction.



A. Strangeness

B. Lepton number

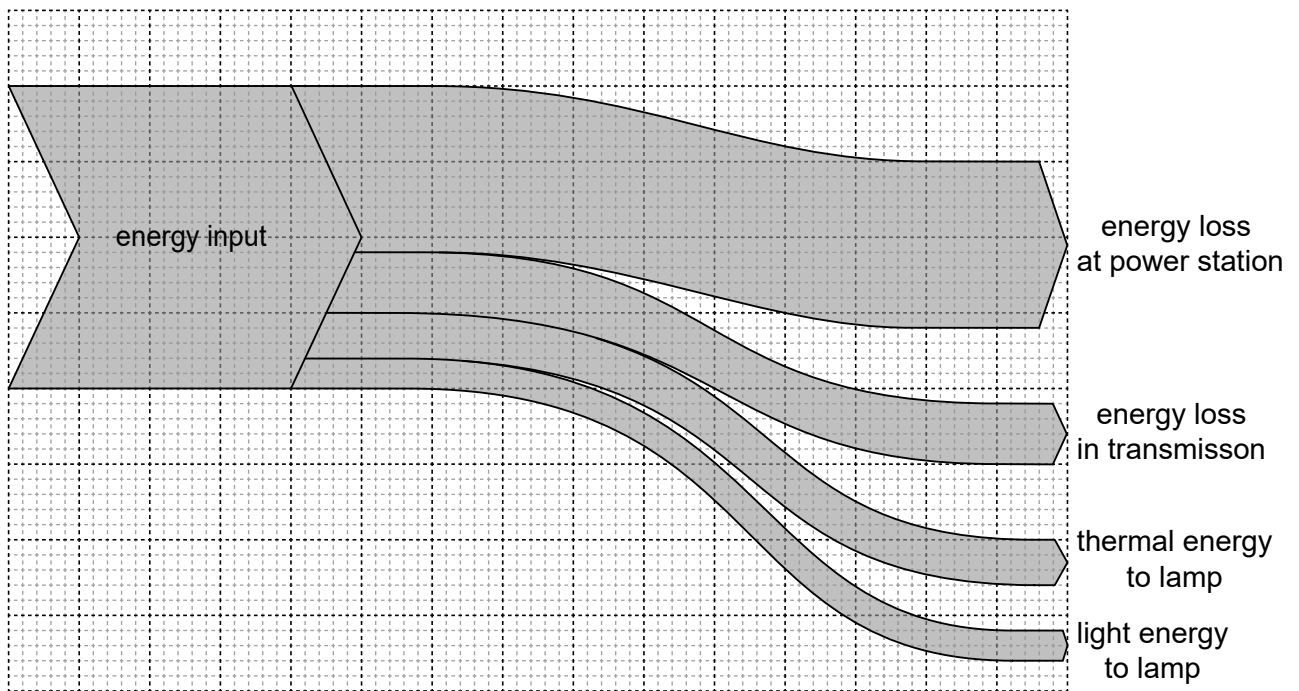
C. Charge

D. Baryon number

21. A wind turbine has a power output p when the wind speed is v . The efficiency of the wind turbine does not change. What is the wind speed at which the power output is $\frac{p}{2}$?

- A. $\frac{v}{4}$
- B. $\frac{v}{\sqrt{8}}$
- C. $\frac{v}{2}$
- D. $\frac{v}{\sqrt[3]{2}}$

22. The Sankey diagram shows the energy input from fuel that is eventually converted to useful domestic energy in the form of light in a filament lamp.



What is true for this Sankey diagram?

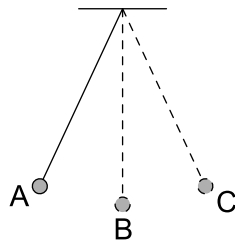
- A. The overall efficiency of the process is 10 %.
- B. Generation and transmission losses account for 55 % of the energy input.
- C. Useful energy accounts for half of the transmission losses.
- D. The energy loss in the power station equals the energy that leaves it.

Turn over

23. What part of a nuclear power station is principally responsible for increasing the chance that a neutron will cause fission?

- A. Moderator
- B. Control rod
- C. Pressure vessel
- D. Heat exchanger

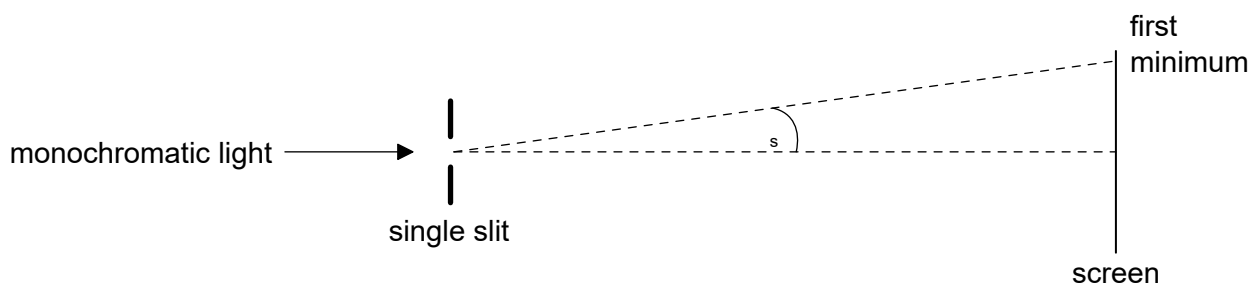
24. A simple pendulum bob oscillates as shown.



At which position is the resultant force on the pendulum bob zero?

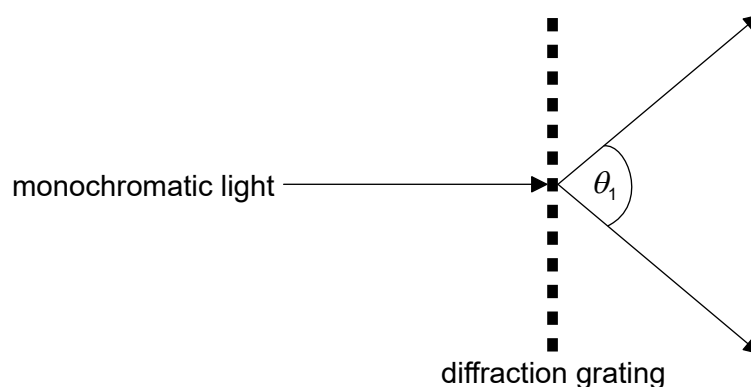
- A. At position A
- B. At position B
- C. At position C
- D. Resultant force is never zero during the oscillation

25. A beam of monochromatic light is incident on a single slit and a diffraction pattern forms on the screen.



What change will increase θ_s ?

- A. Increase the width of the slit
 - B. Decrease the width of the slit
 - C. Increase the distance between the slit and the screen
 - D. Decrease the distance between the slit and the screen
26. A beam of monochromatic light is incident on a diffraction grating of N lines per unit length. The angle between the first orders is θ_1 .



What is the wavelength of the light?

- A. $\frac{\sin \theta_1}{N}$
- B. $N \sin \theta_1$
- C. $N \sin \left(\frac{\theta_1}{2} \right)$
- D. $\frac{\sin \left(\frac{\theta_1}{2} \right)}{N}$

Turn over

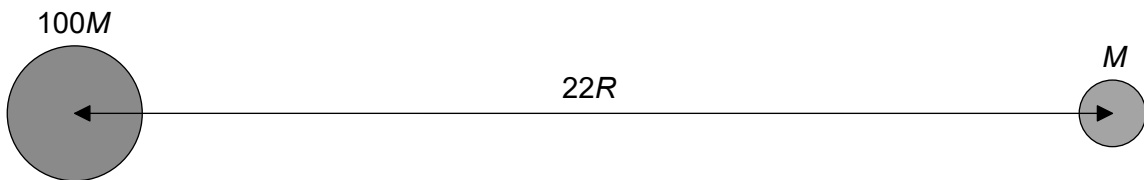
27. A train is approaching an observer with constant speed

$$\frac{c}{34}$$

where c is the speed of sound in still air. The train emits sound of wavelength λ . What is the observed speed of the sound and observed wavelength as the train approaches?

	Speed of sound	Wavelength
A.	c	$\frac{33\lambda}{34}$
B.	$\frac{35c}{34}$	$\frac{33\lambda}{34}$
C.	c	λ
D.	$\frac{35c}{34}$	λ

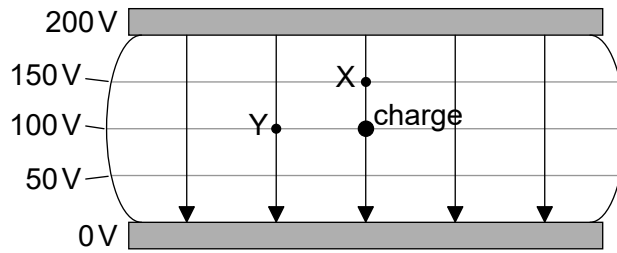
28. A moon of mass M orbits a planet of mass $100M$. The radius of the planet is R and the distance between the centres of the planet and moon is $22R$.



What is the distance from the centre of the planet at which the total gravitational potential has a maximum value?

- A. $2R$
- B. $11R$
- C. $20R$
- D. $2R$ and $20R$

29. The diagram shows the electric field and the electric equipotential surfaces between two charged parallel plates. The potential difference between the plates is 200 V.



What is the work done, in nJ, by the electric field in moving a negative charge of magnitude 1 nC from the position shown to X and to Y?

	To X	To Y
A.	50	0
B.	-50	0
C.	50	100
D.	-50	-100

30. A positive point charge is placed above a metal plate at zero electric potential. Which diagram shows the pattern of electric field lines between the charge and the plate?

A.

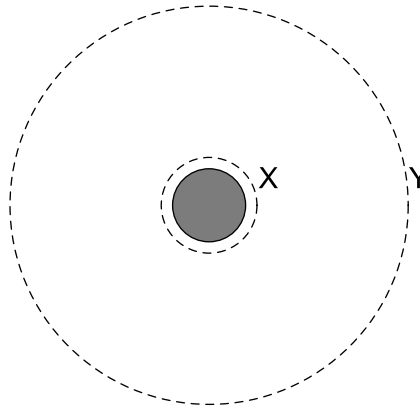
B.

C.

D.

Turn over

31. A satellite orbiting a planet moves from orbit X to orbit Y.



What is the change in the kinetic energy and the change in the gravitational potential energy as a result?

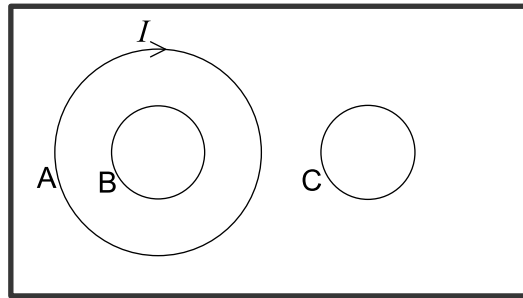
	Kinetic energy	Gravitational potential energy
A.	increases	increases
B.	increases	decreases
C.	decreases	increases
D.	decreases	decreases

32. The mass of the Earth is M_E and the mass of the Moon is M_M . Their respective radii are R_E and R_M .

Which is the ratio $\frac{\text{escape speed from the Earth}}{\text{escape speed from the Moon}}$?

- A. $\sqrt{\frac{M_M R_M}{M_E R_E}}$
- B. $\sqrt{\frac{M_E R_E}{M_M R_M}}$
- C. $\sqrt{\frac{M_E R_M}{M_M R_E}}$
- D. $\sqrt{\frac{M_M R_E}{M_E R_M}}$

33. The current I flowing in loop A in a clockwise direction is increasing so as to induce a current both in loops B and C. All three loops are on the same plane.

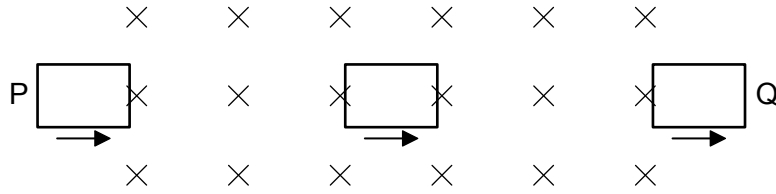


What is the direction of the induced currents in loop B and loop C?

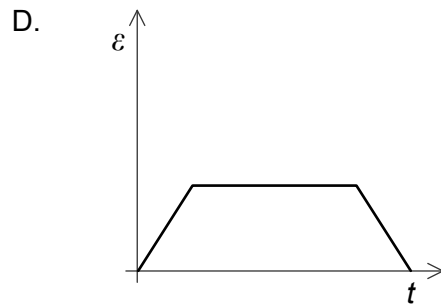
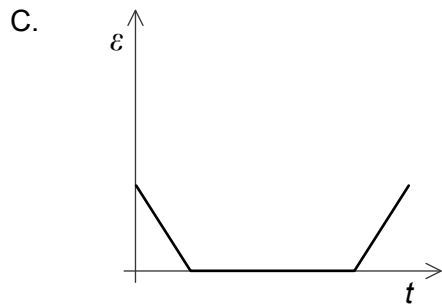
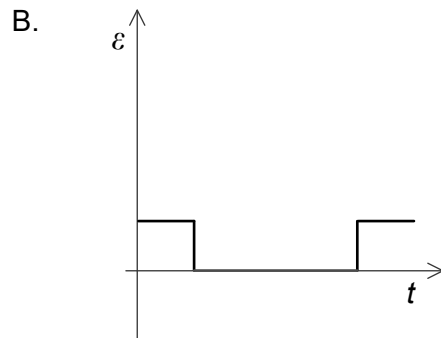
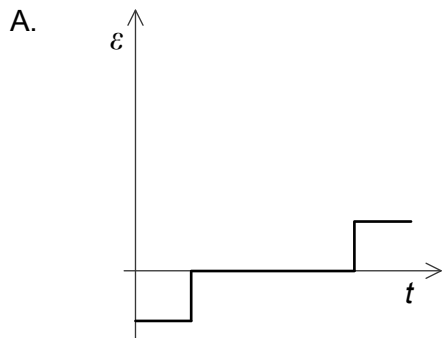
	Loop B	Loop C
A.	clockwise	clockwise
B.	clockwise	anti-clockwise
C.	anti-clockwise	clockwise
D.	anti-clockwise	anti-clockwise

Turn over

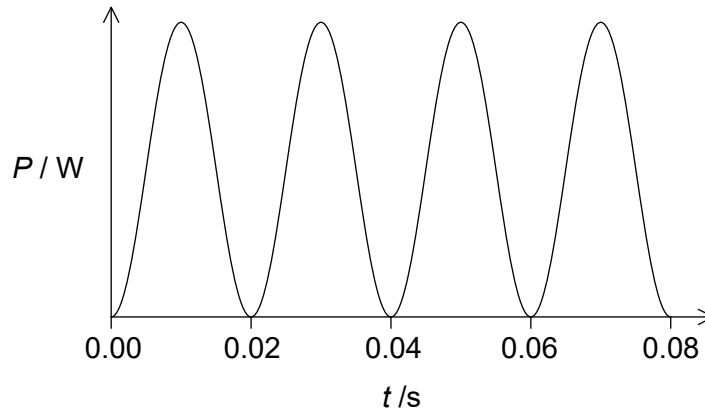
34. A rectangular flat coil moves at constant speed through a uniform magnetic field. The direction of the field is into the plane of the paper.



Which graph shows the variation with time t , of the induced emf ε in the coil as it moves from P to Q?



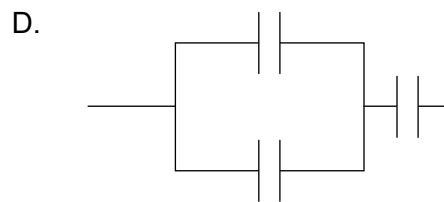
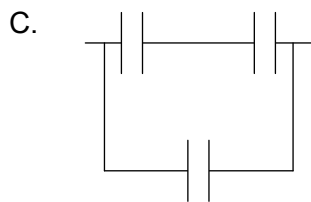
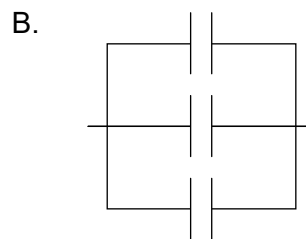
35. The graph shows the power dissipated in a resistor of $100\ \Omega$ when connected to an alternating current (ac) power supply of root mean square voltage (V_{rms}) $60\ \text{V}$.



What are the frequency of the ac power supply and the average power dissipated in the resistor?

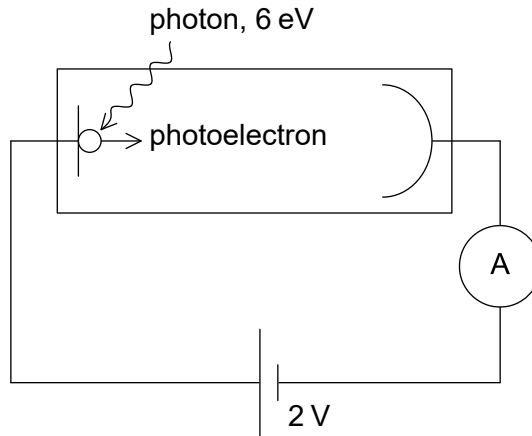
	Frequency of the ac power supply / Hz	Average power dissipated in the resistor / W
A.	25	36
B.	50	36
C.	25	18
D.	50	18

36. Three capacitors, each one with a capacitance C , are connected such that their combined capacitance is $1.5C$. How are they connected?



Turn over

37. A photoelectric cell is connected in series with a battery of emf 2 V. Photons of energy 6 eV are incident on the cathode of the photoelectric cell. The work function of the surface of the cathode is 3 eV.



What is the maximum kinetic energy of the photoelectrons that reach the anode?

- A. 1 eV
 - B. 3 eV
 - C. 5 eV
 - D. 8 eV
38. Which of the following is evidence for the wave nature of the electron?
- A. Continuous energy spectrum in β^- decay
 - B. Electron diffraction from crystals
 - C. Existence of atomic energy levels
 - D. Existence of nuclear energy levels
39. An electron of initial energy E tunnels through a potential barrier. What is the energy of the electron after tunnelling?
- A. greater than E
 - B. E
 - C. less than E
 - D. zero

40. Two samples X and Y of different radioactive isotopes have the same initial activity. Sample X has twice the number of atoms as sample Y. The half-life of X is T . What is the half-life of Y?
- A. $2T$
 - B. T
 - C. $\frac{T}{2}$
 - D. $\frac{T}{4}$
-