Diploma Programme
Programme du diplôme
Programa del Diploma

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]**.

2223 – 6507

28 pages

1. The ratio of the diameter of an atom to the diameter of its nucleus is:

A. 10^1

B. 10^3

C. 10^5

D. 10^7

2. The kinetic energy of a body is determined from measurements of its momentum p and its mass m.

The percentage uncertainties in the measurements are:

p	$\pm 3\,\%$
m	$\pm 4\,\%$

What is the percentage uncertainty in the kinetic energy?

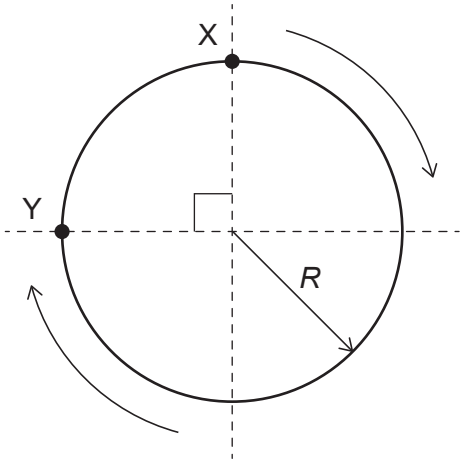
A. 7 %

B. 10 %

C. 13 %

D. 14 %

3. A car travels clockwise around a circular track of radius *R*. What is the magnitude of displacement from X to Y?



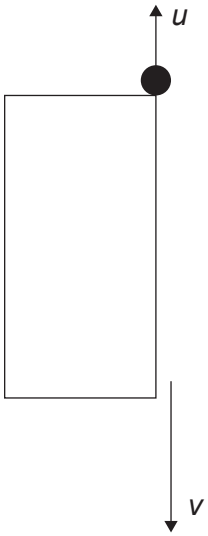
A. $R\frac{3\pi}{2}$

B. $R\frac{\pi}{2}$

C. $R\sqrt{2}$

D. R

4. A stone of mass m is projected vertically upwards with speed u from the top of a cliff. The speed of the stone when it is just about to hit the ground is v.



What is the magnitude of the change in momentum of the stone?

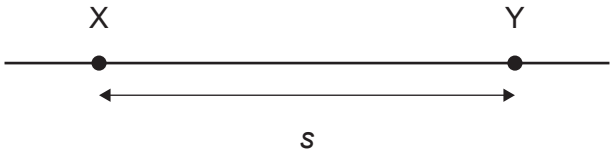
A. $m\left(\frac{v+u}{2}\right)$

B. $m\left(\frac{v-u}{2}\right)$

C. $m(v+u)$

D. $m(v-u)$

5. A car accelerates uniformly. The car passes point X at time t_1 with velocity v_1 and point Y at time t_2 with velocity v_2. The distance XY is s.



The following expressions are proposed for the magnitude of its acceleration a:

I. $a = \dfrac{2s}{(t_2 - t_1)^2}$

II. $a = \dfrac{v_2^2 - v_1^2}{2s}$

III. $a = \dfrac{v_2 - v_1}{t_2 - t_1}$

Which is correct?

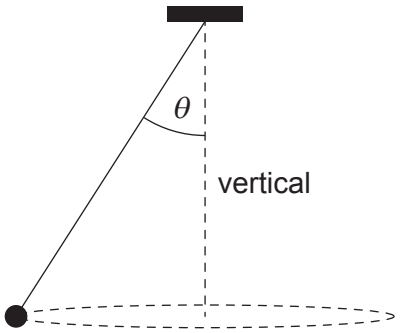
A. I and II only

B. I and III only

C. II and III only

D. I, II and III

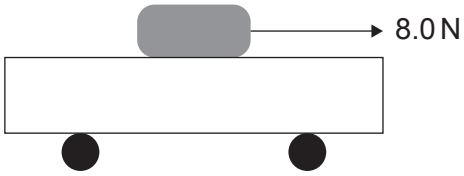
6. A ball attached to a string is made to rotate with constant speed along a horizontal circle. The string is attached to the ceiling and makes an angle of $\theta°$ with the vertical. The tension in the string is *T.*



What is correct about the horizontal component and vertical component of the net force on the ball?

	Horizontal component	**Vertical component**
A.	$T\cos\theta$	$T\sin\theta$
B.	$T\sin\theta$	$T\cos\theta$
C.	$T\cos\theta$	0
D.	$T\sin\theta$	0

7. A block of mass 2.0 kg is placed on a trolley of mass 5.0 kg, moving horizontally. A force of 8.0 N is applied to the block which slides on the surface of the trolley. The frictional force between the trolley and the ground is zero.



The trolley accelerates at a rate of 1.0 m s^{-2}. What is the coefficient of dynamic friction between the block and the trolley?

A. 0.05

B. 0.15

C. 0.25

D. 0.35

8. The input power of an electric motor is 200 W. It is used to raise a mass of 10 kg at constant speed. If the efficiency of the motor is 40 %, through what height will the mass be raised in 1 second?

A. 0.5 m

B. 0.8 m

C. 1.2 m

D. 2.0 m

9. The temperature of an object is changed from θ_1 °C to θ_2 °C. What is the change in temperature measured in kelvin?

A. $(\theta_2 - \theta_1)$

B. $(\theta_2 - \theta_1) + 273$

C. $(\theta_2 - \theta_1) - 273$

D. $273 - (\theta_2 - \theta_1)$

10. A metal cube X of length L is heated gaining thermal energy Q. Its temperature rises by ΔT. A second cube Y, of length $2L$, made of the same material, gains thermal energy of $2Q$.

What is the temperature rise of Y?

A. $\frac{\Delta T}{8}$

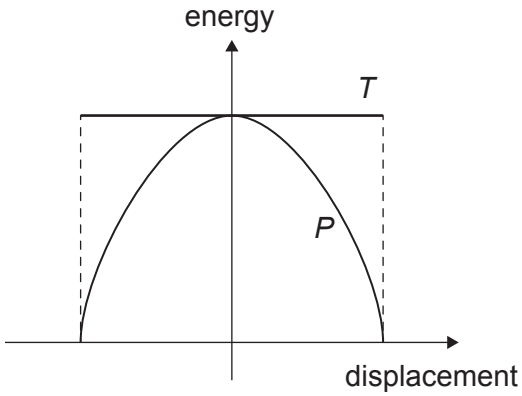
B. $\frac{\Delta T}{4}$

C. ΔT

D. $2\Delta T$

11. Which graph represents the variation with displacement of the potential energy P and the total energy T of a system undergoing simple harmonic motion (SHM)?

A.



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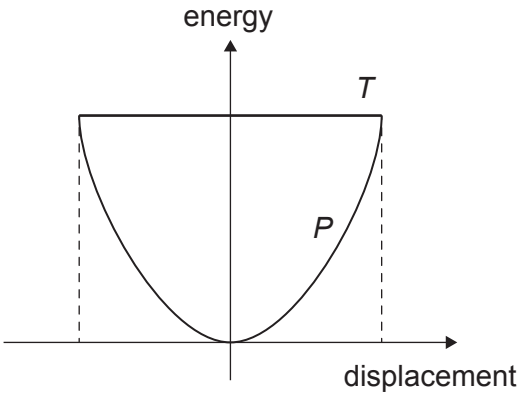

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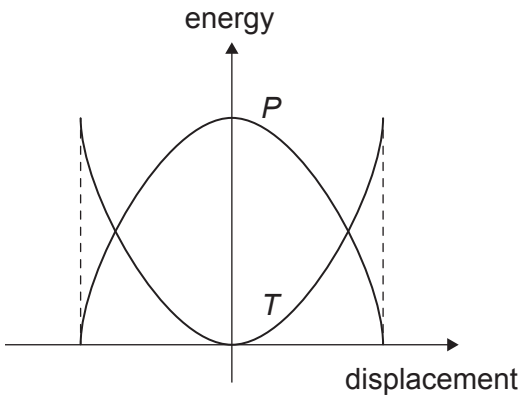

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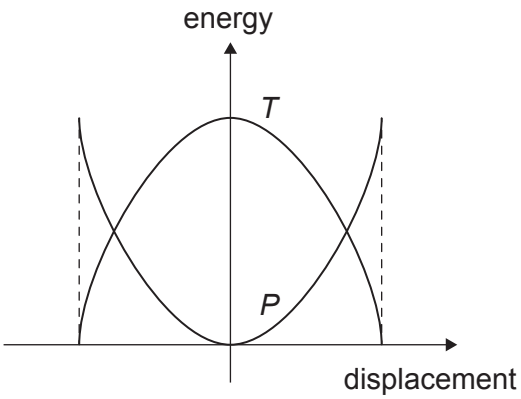


12. A wave is polarized. What **must** be correct about the wave?

It is a…

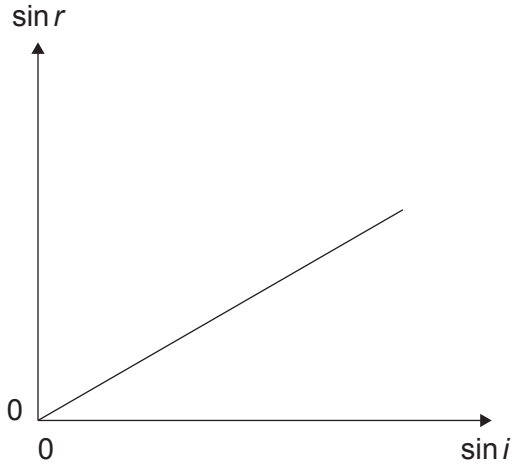
A. transverse wave.

B. longitudinal wave.

C. standing wave.

D. travelling wave.

13. A group of students perform an experiment to find the refractive index of a glass block. They measure various values of the angle of incidence i and angle of refraction r for a ray entering the glass from air. They plot a graph of the $\sin r$ against $\sin i$.



They determine the gradient of the graph to be m.

Which of the following gives the critical angle of the glass?

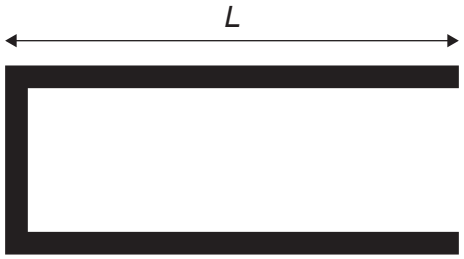
A. $\sin^{-1}(m)$

B. $\sin^{-1}\left(\frac{1}{m}\right)$

C. m

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

14. A standing wave is formed in a pipe open at one end and closed at the other. The length of the pipe is L and the speed of sound in the pipe is V.



n is a positive integer.

What expression is correct about the frequencies of the harmonics in the pipe?

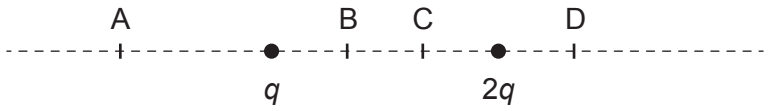
A. $\frac{(2n-1)V}{2L}$

B. $\frac{(2n-1)V}{4L}$

C. $\frac{nV}{2L}$

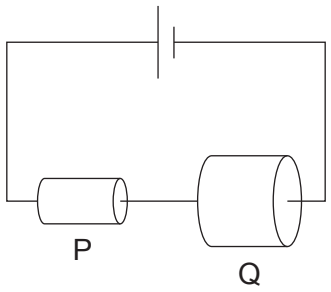
D. $\frac{nV}{4L}$

15. Two positive charges of magnitude q and $2q$ are fixed as shown. At which position is the electric field, due to these charges, equal to zero?



16. P and Q are two conductors of the same material connected in series. Q has a diameter twice that of P.

What is $\frac{\text{drift speed of electrons in P}}{\text{drift speed of electrons in Q}}$?



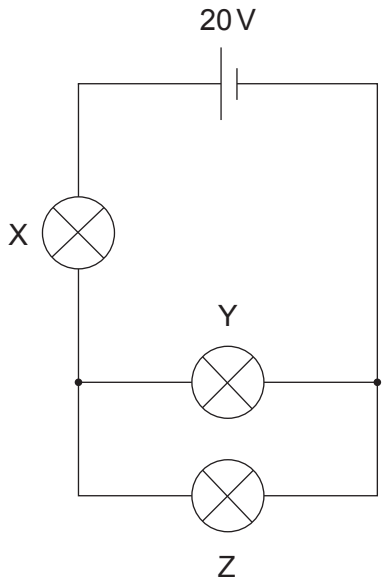
A. 4

B. 2

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

D. $\frac{1}{4}$

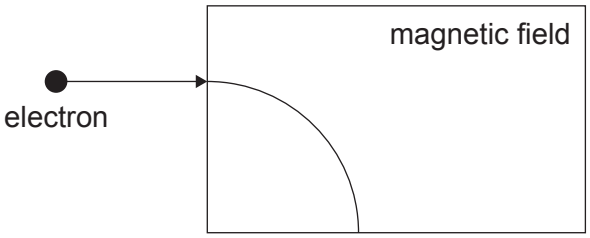
17. Three lamps (X, Y and Z) are connected as shown in the circuit. The emf of the cell is 20 V. The internal resistance of the cell is negligible. The power dissipated by X, Y and Z is 10 W, 20 W and 20 W respectively.



What is the voltage across Lamp X and Lamp Y?

	Lamp X	**Lamp Y**
A.	16 V	4 V
B.	4 V	16 V
C.	4 V	8 V
D.	16 V	16 V

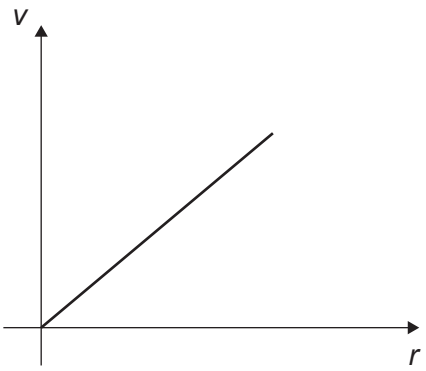
18. An electron enters a region of uniform magnetic field at a speed *v*. The direction of the electron is perpendicular to the magnetic field. The path of the electron inside the magnetic field is circular with radius *r.*



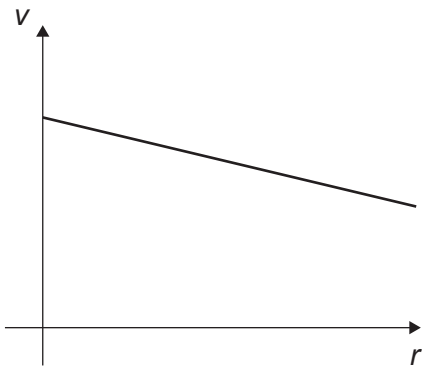
The speed of the electron is varied to obtain different values of *r*.

Which graph represents the variation of speed *v* with *r*?

A.



B.



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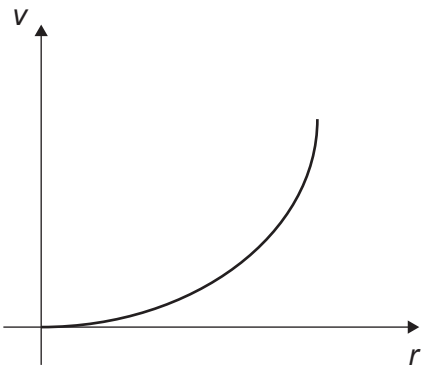

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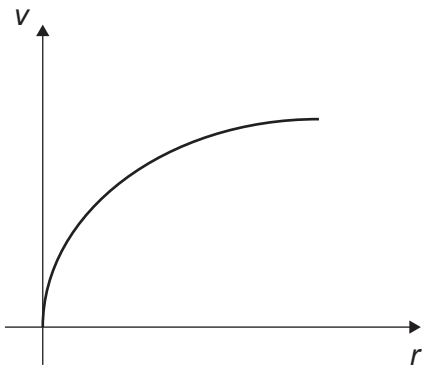
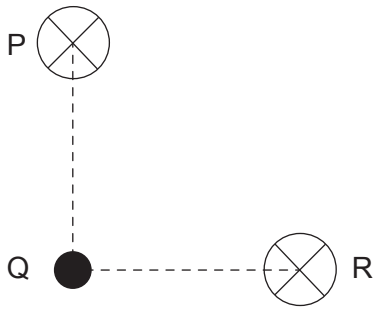


19. P and R are parallel wires carrying the same current into the plane of the paper. P and R are equidistant from a point Q. The line PQ is perpendicular to the line RQ.



The magnetic field due to P at Q is *X*. What is the magnitude of the resultant magnetic field at Q due to both wires?

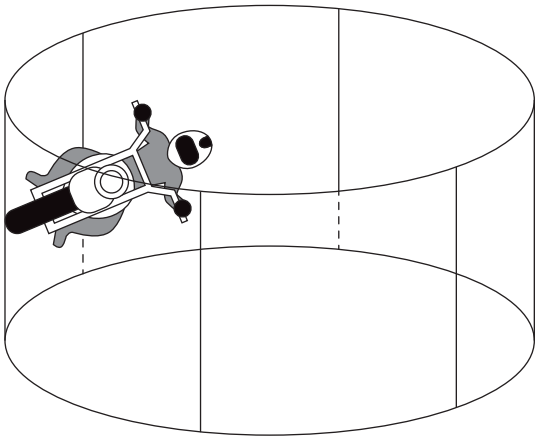
A. $\frac{X}{2}$

B. X

C. $X\sqrt{2}$

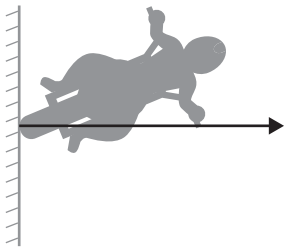
D. $2X$

20. A stuntman rides a motorcycle on the inside surface of a cylinder.

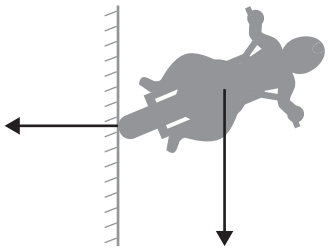


Which is the correct free-body diagram showing all the forces acting on the cyclist at that position?

A.



B.



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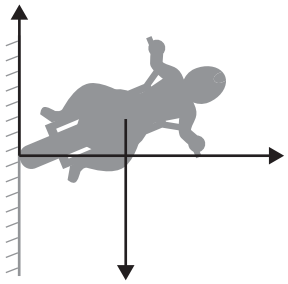

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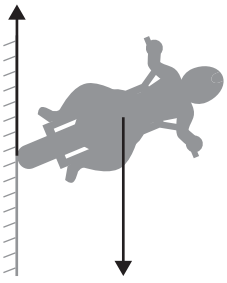
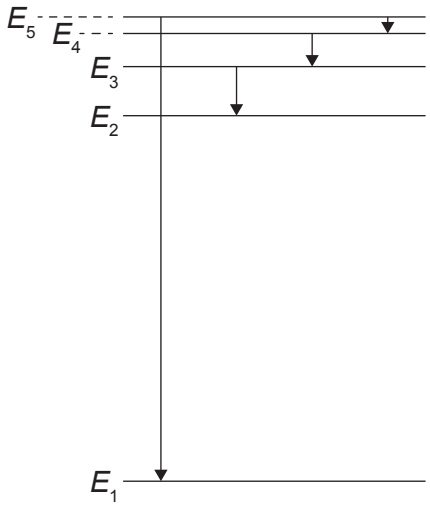
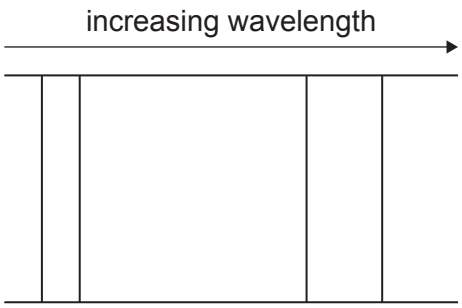


21. The energy levels E of an atom are shown.

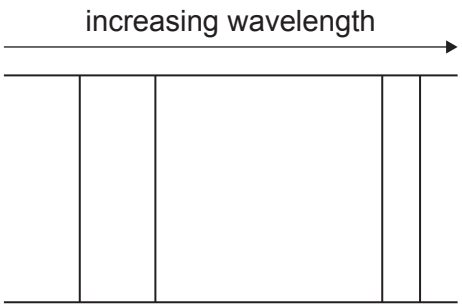


Which emission spectrum represents the transitions?

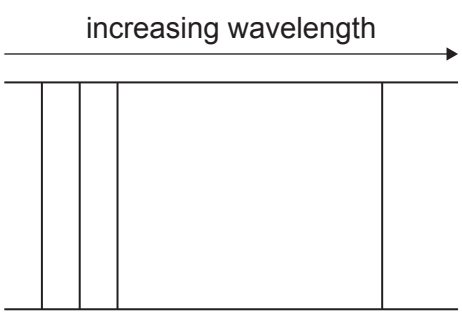
A.



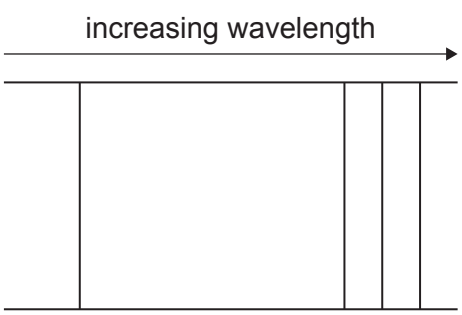
B.



C.



D.



22. Three claims are made about the structure of the atom.

I. Most of the atom is empty space.

II. The positive charge of the atom is concentrated in a small volume.

III. The electrons have discrete energy levels.

Which of these claims can be deduced from the Rutherford-Geiger-Marsden scattering experiment?

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

23. This interaction between a proton and a pion violates two or more conservation laws.

$$p + \pi^- \rightarrow K^- + \pi^+$$

Quark composition of particles:

$\pi^- = d\bar{u}$, $\pi^+ = u\bar{d}$, $K^- = s\bar{u}$, $p = uud$

Which laws are violated by this interaction?

I. Conservation of charge

II. Conservation of strangeness

III. Conservation of baryon number

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

24. A student claims that the following three factors may affect the rate of global warming.

I. Increased volcanic activity

II. Increased solubility of carbon dioxide (CO_2) in the ocean

III. Increased rate of deforestation

Which factors can **increase** the rate of global warming?

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

25. Two surfaces X and Y emit radiation of the same surface intensity. X emits a radiation of peak wavelength twice that of Y.

What is $\frac{\text{emissivity of X}}{\text{emissivity of Y}}$?

A. $\frac{1}{16}$

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

C. 2

D. 16

26. A simple pendulum oscillates with frequency f. The length of the pendulum is halved. What is the new frequency of the pendulum?

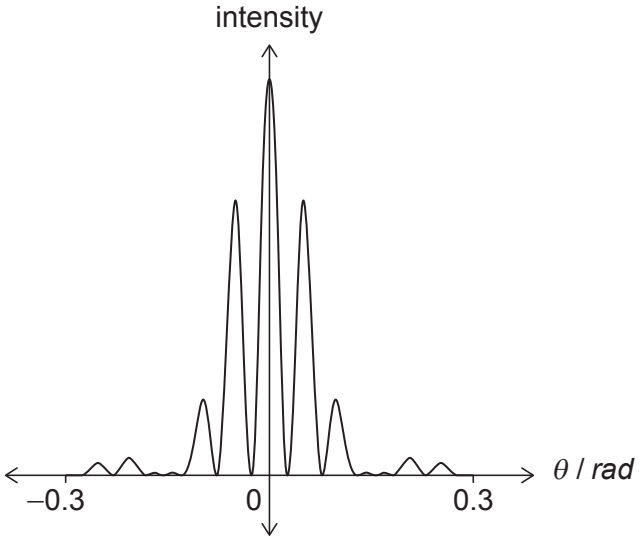
A. $2f$

B. $\sqrt{2}f$

C. $\frac{f}{\sqrt{2}}$

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

27. The intensity pattern of monochromatic light of wavelength λ, is projected onto a screen.

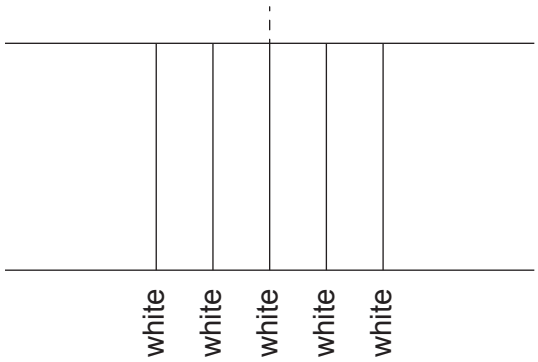


What combination produces this pattern?

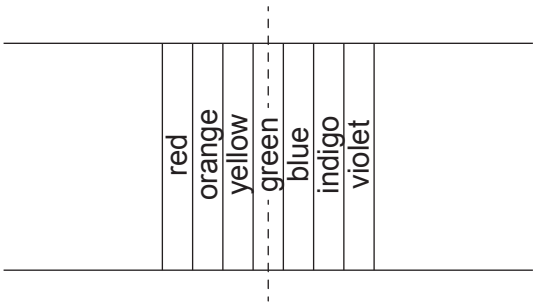
	Number of slits	Width of slits
A.	1	smaller than λ
B.	1	greater than λ
C.	2	smaller than λ
D.	2	greater than λ

28. What is the pattern observed when white light passes through a diffraction grating?

A.



B.



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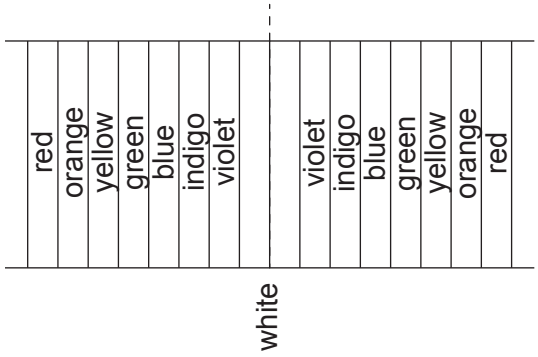
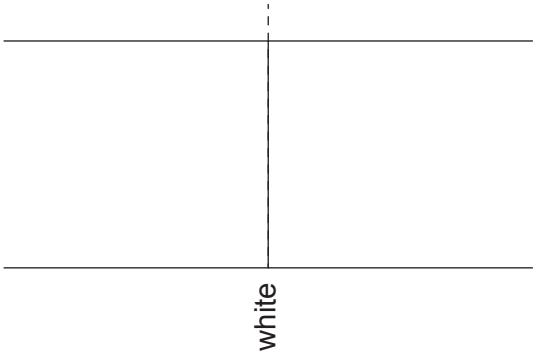
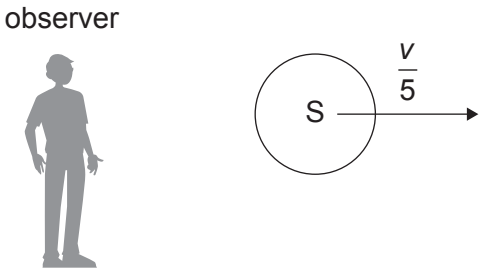


D.



29. Source S produces sound waves of speed *v* and frequency f. S moves with constant velocity $\frac{v}{5}$ away from a stationary observer.



What is the frequency measured by the observer?

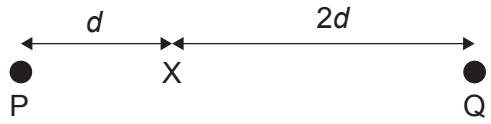
A. $\frac{4}{5}f$

B. $\frac{5}{6}f$

C. $\frac{6}{5}f$

D. $\frac{5}{4}f$

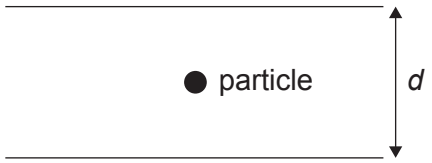
30. Two isolated point masses, P of mass m and Q of mass $2m$, are separated by a distance $3d$. X is a point a distance d from P and $2d$ from Q.



What is the net gravitational field strength at X and the net gravitational potential at X?

	Net gravitational field strength at X	Net gravitational potential at X
A.	$\frac{Gm}{d^2}$	0
B.	$\frac{Gm}{d^2}$	$-\frac{2Gm}{d}$
C.	$\frac{Gm}{2d^2}$	0
D.	$\frac{Gm}{2d^2}$	$-\frac{2Gm}{d}$

31. A negatively charged particle is stationary halfway between two horizontal charged plates. The plates are separated by a distance *d* with potential difference *V* between them.



What is the magnitude of the electric field and direction of the electric field at the position of the particle?

	Magnitude of electric field	Direction of electric field
A.	$\frac{2V}{d}$	up
B.	$\frac{V}{d}$	up
C.	$\frac{2V}{d}$	down
D.	$\frac{V}{d}$	down

32. The escape speed from the surface of earth is v_{esc}. The radius of earth is *R*. A satellite of mass m is in orbit at a height $\frac{R}{4}$ above the surface of the Earth. What is the energy required to move the satellite to infinity?

A. $\frac{mv_{esc}^2}{5}$

B. $\frac{2mv_{esc}^2}{5}$

C. mv_{esc}^2

D. $2mv_{esc}^2$

33. Which law is equivalent to the law of conservation of energy?

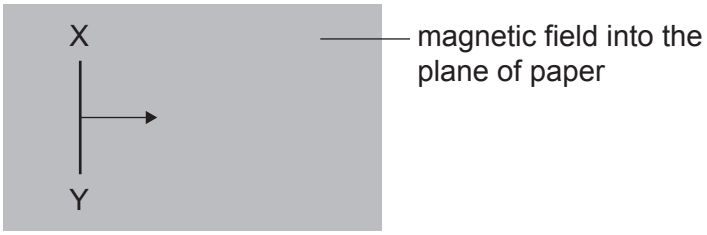
A. Coulomb’s law

B. Ohm’s Law

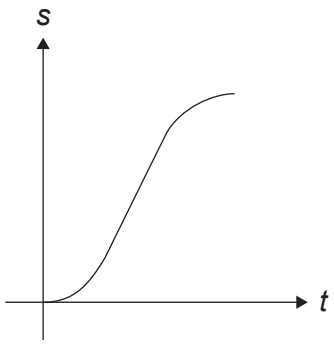
C. Newton’s first law

D. Lenz’s law

34. Wire XY moves perpendicular to a magnetic field in the direction shown.

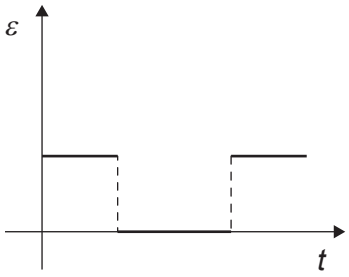


The graph shows the variation with time of the displacement of XY.

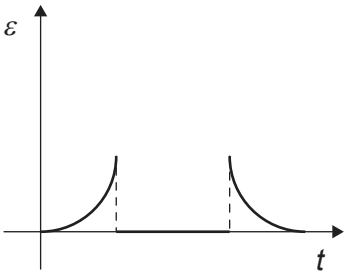


What is the graph of the electromotive force (emf) ε induced across XY?

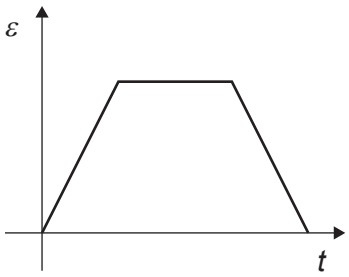
A.



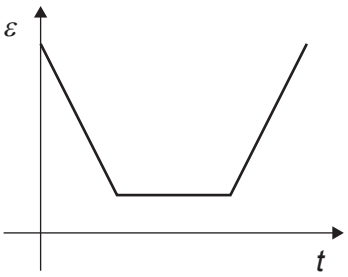
B.



C.



D.



35. Three changes are made to a transformer.

I. increasing the thickness of wire in the coils

II. laminating the soft iron core

III. using wire with lower resistivity

Which changes will reduce power losses in the transformer?

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

36. A resistor of resistance R is connected to an alternating current power supply. The peak voltage across the resistor is V_0.

What is the mean power dissipated by the resistor?

A. $\frac{V_0^2\sqrt{2}}{R}$

B. $\frac{V_0^2}{R}$

C. $\frac{V_0^2}{R\sqrt{2}}$

D. $\frac{V_0^2}{2R}$

37. A gamma ray can split into an electron and a positron when it passes through certain materials. Which process describes this phenomenon?

A. Pair production

B. Pair annihilation

C. Nuclear fission

D. Radioactive decay

38. In the Bohr model for hydrogen, the radius of the electron orbit in the n = 2 state is four times that of the radius in the n = 1 state.

What is $\frac{\text{speed of the electron in the n = 2 state}}{\text{speed of the electron in the n =1 state}}$?

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

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

C. 2

D. 4

39. Which statement about atomic nuclei is correct?

The density is…

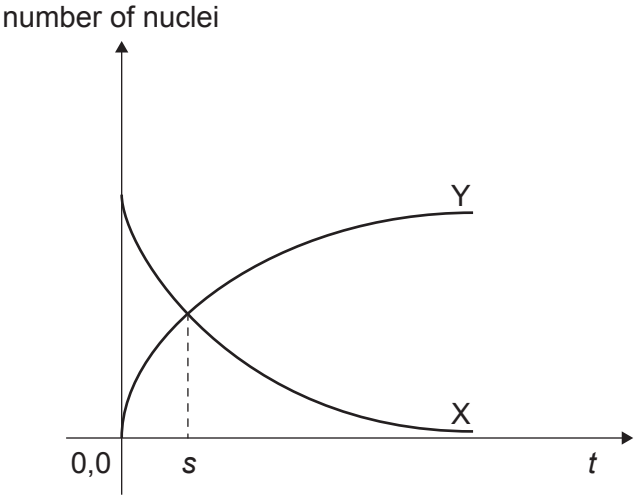
A. directly proportional to mass number.

B. inversely proportional to nuclear radius.

C. inversely proportional to volume.

D. constant for all nuclei.

40. Radioactive nuclide X decays into a stable nuclide Y. The decay constant of X is λ. The variation with time t of number of nuclei of X and Y are shown on the same axes.



What is the expression for s?

A. $\frac{\ln 2}{\lambda}$

B. $\frac{1}{\lambda}$

C. $\frac{\lambda}{\ln 2}$

D. $\ln 2$

References: