Diploma Programme
Programme du diplôme
Programa del Diploma

Physics
Higher level
Paper 1

25 October 2023

Zone A afternoon | **Zone B** afternoon | **Zone C** 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].**

8823 – 6513

21 pages

1. The resistive force F that acts on an object moving through a fluid at speed v is given by $F = kv$ where k is a constant. What is the unit of k?

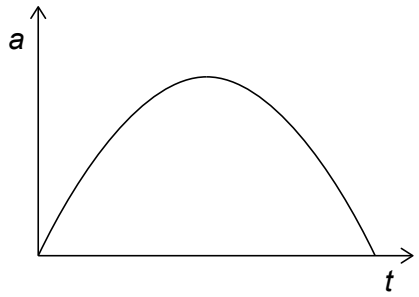
A. $\mathrm{N\,s^{-1}}$

B. $\mathrm{N\,m\,s^{-1}}$

C. $\mathrm{kg\,m^{2}\,s^{-3}}$

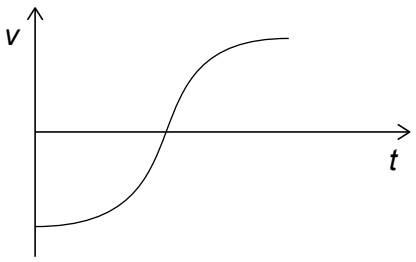
D. $\mathrm{kg\,s^{-1}}$

2. The graph shows the variation of the acceleration a with time t of an object moving in a straight line.



Which graph shows the variation of the velocity v of the object with time t?

A.



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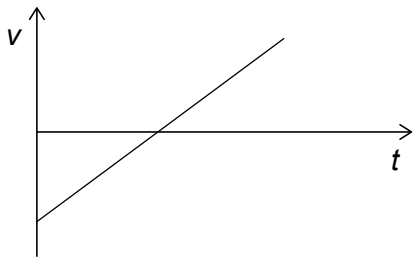

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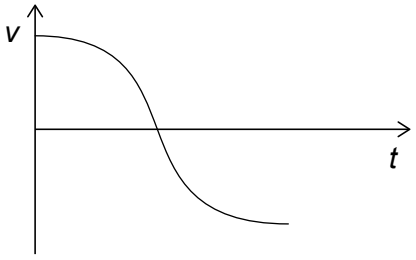

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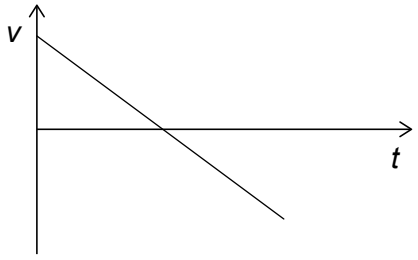
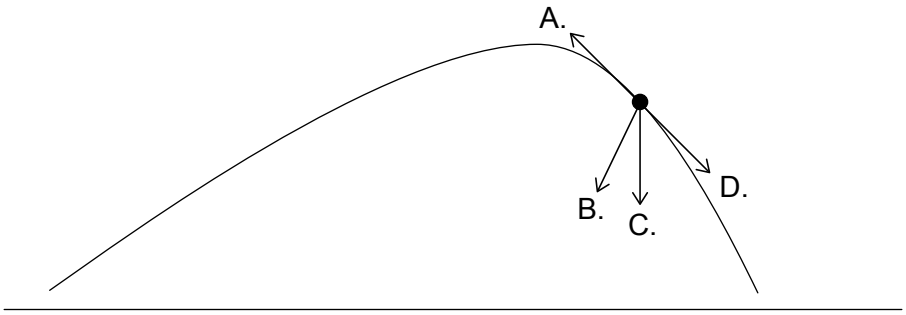
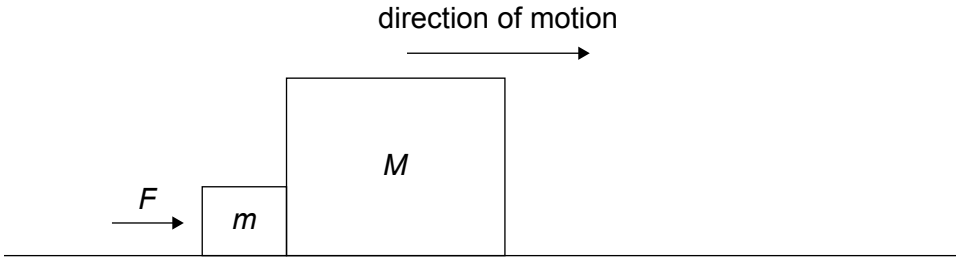


3. A projectile moving in air has the path shown. What is the direction of the net force at the point shown?



4. The diagram shows two blocks of mass m and M in contact on a frictionless surface. A force F is applied on the block of mass m and causes the blocks to move with an acceleration a.



What is the force that the block of mass M is exerting on the block of mass m?

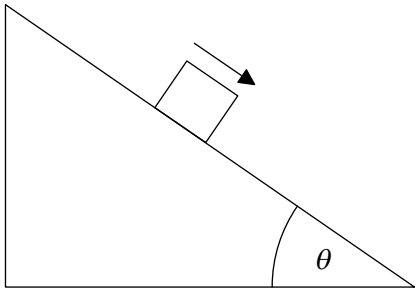
A. ma

B. Ma

C. $(M+m)a$

D. $\frac{m}{M+m}a$

5. The diagram shows a block of mass *m* sliding at constant speed down an inclined plane. The plane makes an angle θ with the horizontal.



The coefficient of dynamic friction between the block and the plane is μ_D and the magnitude of the normal reaction force on the block is *N*. What is θ?

A. $\cos^{-1}\left(\frac{mg}{\mu_D N}\right)$

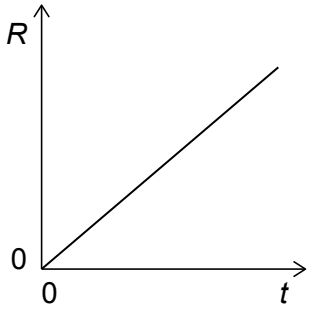
B. $\cos^{-1}\left(\frac{\mu_D N}{mg}\right)$

C. $\sin^{-1}\left(\frac{mg}{\mu_D N}\right)$

D. $\sin^{-1}\left(\frac{\mu_D N}{mg}\right)$

6. An object falls from rest in vacuum. R is the **rate of the change** of kinetic energy with time t. How does R vary with t?

A.



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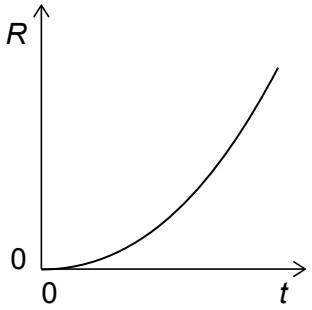

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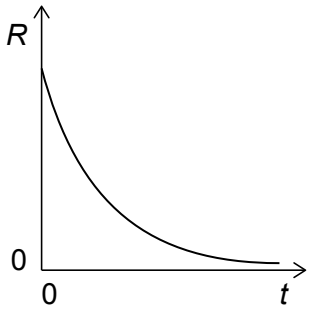

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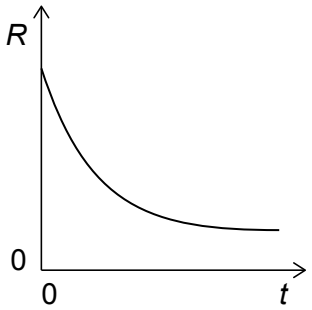


7. X has a mass that is twice the mass of Y. The kinetic energy of X is four times that of Y.

What is the value of $\frac{\text{momentum of X}}{\text{momentum of Y}}$?

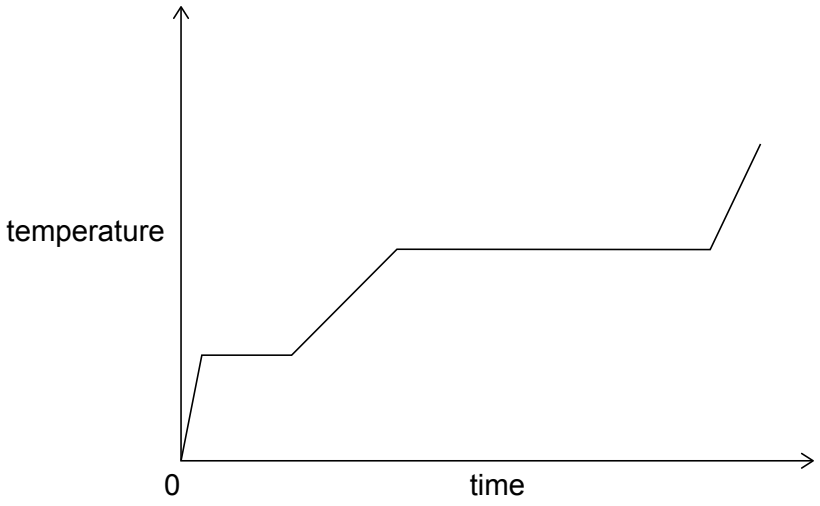
A. $\sqrt{2}$

B. 2

C. $2\sqrt{2}$

D. 4

8. Energy is supplied at a constant rate to a fixed mass of a substance. The graph shows the variation of the temperature of the substance with time.



Which statement about the substance is correct?

A. Specific latent heat of vaporization > specific latent heat of fusion

B. Specific latent heat of fusion > specific latent heat of vaporization

C. Specific heat capacity of solid > specific heat capacity of liquid

D. Specific heat capacity of vapour > specific heat capacity of liquid

9. For a fixed mass of an ideal gas the pressure is proportional to…

A. density and volume.

B. density and absolute temperature.

C. absolute temperature and volume.

D. absolute temperature only.

10. What is the $\frac{\text{number of atoms in 20 g of Neon-20}}{\text{number of atoms in 40 g of Krypton-80}}$?

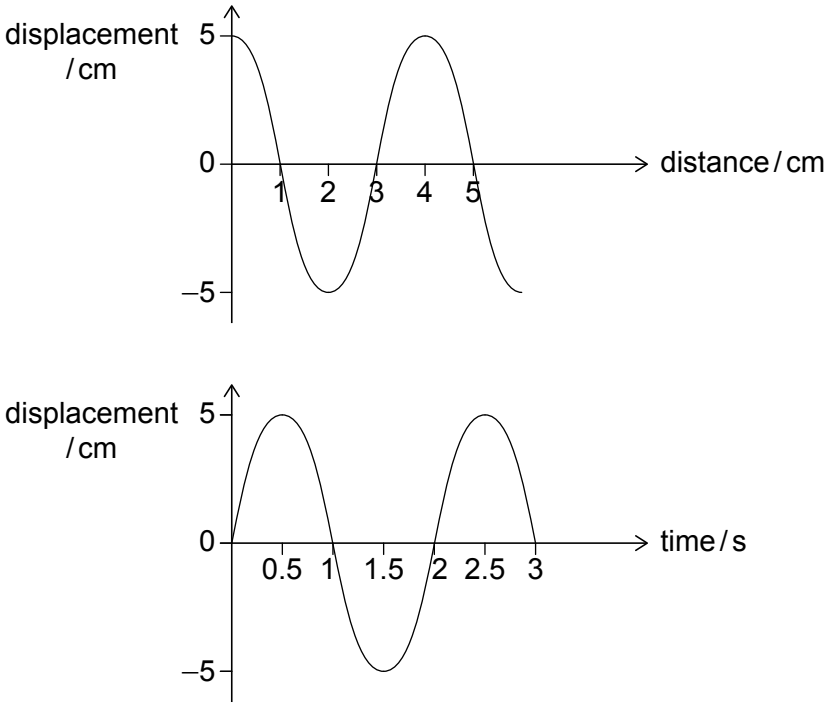
A. $\frac{1}{4}$

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

C. 2

D. 4

11. A wave is travelling on a string. The graphs show the variation of the displacement of the string with distance and the variation of the displacement of a particle on the string with time.



What is the speed of the wave?

A. $2.0\,\text{cm}\,\text{s}^{-1}$

B. $2.5\,\text{cm}\,\text{s}^{-1}$

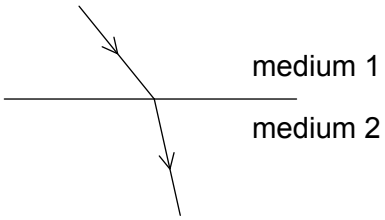
C. $8.0\,\text{cm}\,\text{s}^{-1}$

D. $10\,\text{cm}\,\text{s}^{-1}$

12. Unpolarized light of intensity I_0 is incident on a polarizer with a vertical axis of polarization. The transmitted intensity of this polarizer is I_1. The light is then incident on a second polarizer with a vertical axis of polarization. The transmitted intensity of this polarizer is I_2. What are I_1 and I_2?

	I_1	I_2
A.	$\frac{I_0}{2}$	$\frac{I_0}{4}$
B.	$\frac{I_0}{2}$	$\frac{I_0}{2}$
C.	I_0	$\frac{I_0}{4}$
D.	I_0	$\frac{I_0}{2}$

13. A wave is travelling from medium 1 to medium 2.



Medium 1 has a refractive index n_1 and medium 2 has a refractive index n_2. The wavelength of the wave in medium 1 is λ_1 and in medium 2 is λ_2. What is correct for the comparison of the refractive indices and wavelengths?

	Refractive indices	**Wavelengths**
A.	$n_1 > n_2$	$\lambda_1 > \lambda_2$
B.	$n_1 > n_2$	$\lambda_1 < \lambda_2$
C.	$n_1 < n_2$	$\lambda_1 > \lambda_2$
D.	$n_1 < n_2$	$\lambda_1 < \lambda_2$

14. The first harmonic of a standing sound wave is established in a tube with one end open and one end closed. When the length of the tube is increased by 0.10 m the next harmonic is formed. What is the wavelength of the sound?

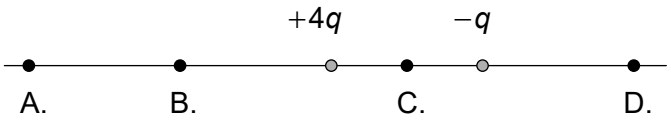
A. 0.10 m

B. 0.13 m

C. 0.20 m

D. 0.40 m

15. Two point charges of $+4q$ and $-q$ are placed a fixed distance apart. Where is the electric field strength equal to zero?



16. A cylinder of copper with diameter d and length L has a resistance R. What is the resistance of a copper cylinder with diameter $2d$ and length $2L$?

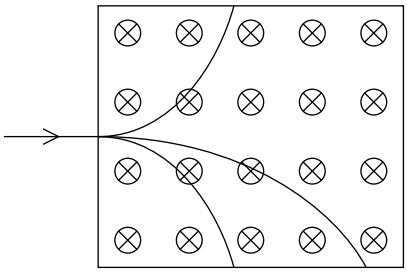
A. $\frac{R}{8}$

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

C. $2R$

D. $8R$

17. The path of three particles with identical magnitude of charge but different mass is shown as they enter a region of uniform magnetic field. The particles have the same initial velocity. The magnetic field is directed into the plane of the paper.



particle X

What is the mass of particle X compared to the other particles and what is the sign of the charge on particle X?

	Mass in comparison	Sign of charge
A.	larger	positive
B.	larger	negative
C.	smaller	positive
D.	smaller	negative

18. The mass of a planet X is 300 times larger than the mass of the Earth and its radius is 10 times larger than the radius of the Earth. What is the gravitational field strength on the surface of planet X in terms of the gravitational field strength g on the surface of Earth?

A. $\frac{g}{30}$

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

C. $3g$

D. $30g$

19. A sample of the artificial element Seaborgium-265 (Sg-265) is created with 4.0×10^{22} atoms. Sg-265 has a half-life of 15 s. How many atoms of Sg-265 remain after one minute?

A. 2.5×10^{21}

B. 5.0×10^{21}

C. 1.0×10^{22}

D. 2.0×10^{22}

20. A π^+ meson can decay as shown in the equation.

$$\pi^+ \rightarrow X + \mu^+$$

Which of the following is correct for particle X and the exchange particle for this interaction?

	Particle X	Exchange particle
A.	ν_μ	W^+
B.	ν_μ	W^-
C.	$\overline{\nu}_\mu$	W^+
D.	$\overline{\nu}_\mu$	W^-

21. Which of the following is **not** considered to be a greenhouse gas?

A. N_2O

B. H_2O

C. O_2

D. CH_4

22. A black body at temperature T (kelvin) has a peak wavelength λ. What is the peak wavelength when the temperature increases by 33 %?

A. $\frac{\lambda}{3}$

B. $\frac{3}{4}\lambda$

C. $\frac{4}{3}\lambda$

D. 3λ

23. A particle is executing simple harmonic oscillations with total energy E and amplitude x_0.

What is the kinetic energy of the particle when the displacement from the equilibrium position is $\frac{x_0}{2}$?

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

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

C. $\frac{3E}{4}$

D. $\frac{E\sqrt{3}}{2}$

24. An interference intensity pattern is obtained in an experiment with 4 slits. What change occurs when the number of slits is increased but the separation of the slits and the width of the slits do not change?

A. The width of the primary maxima decreases.

B. The position of the primary maxima changes.

C. The number of secondary maxima decreases.

D. The intensity of the secondary maxima increases.

25. A diffraction grating with 6000 slits is used to resolve two spectral lines. The mean wavelength of the lines is 500 nm and the difference in their wavelength is 0.050 nm. What is the minimum order at which the diffraction grating can resolve the two lines?

A. First order

B. Second order

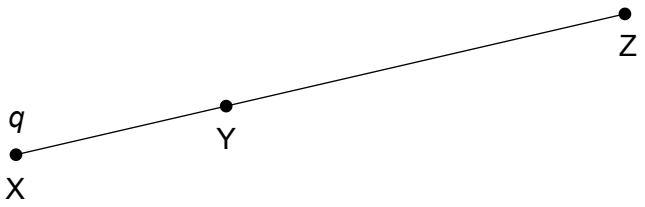
C. Third order

D. Fourth order

26. A siren emits sound of wavelength λ and speed c when at rest. The siren now moves towards a stationary observer at speed v. What is the wavelength and the speed of the sound received by the observer when v is much less than c?

	Wavelength	**Speed**
A.	$\frac{v\lambda}{c}$	c
B.	$\left(1-\frac{v}{c}\right)\lambda$	c
C.	$\frac{v\lambda}{c}$	$c+v$
D.	$\left(1-\frac{v}{c}\right)\lambda$	$c+v$

27. An isolated point charge q is located at point X. Two other points Y and Z are such that $YZ = 2XY$.



What is $\frac{\text{electric field at Y}}{\text{electric field at Z}}$?

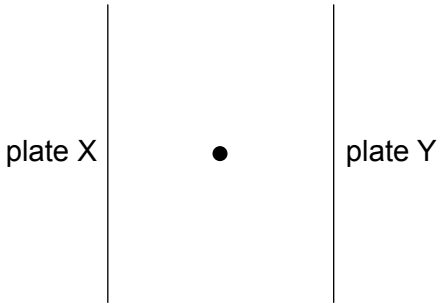
A. $\frac{1}{9}$

B. $\frac{1}{3}$

C. 3

D. 9

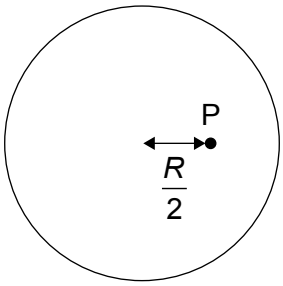
28. Two very long parallel plates, X and Y, have equal and opposite charges. The potential on X is V_X and that on Y is V_Y where $V_X > V_Y$. A point particle of positive charge q and mass m is held at rest midway between the plates.



The particle is then released. Which plate will the particle move toward and what kinetic energy does it have when it reaches the plate?

	Plate	Kinetic energy
A.	X	$q(V_X - V_Y)$
B.	X	$\frac{q(V_X - V_Y)}{2}$
C.	Y	$q(V_X - V_Y)$
D.	Y	$\frac{q(V_X - V_Y)}{2}$

29. A hollow metallic sphere of radius R has a positive charge Q. P is a point a distance $\frac{R}{2}$ from the centre of the sphere.



What are the electric potential and the electric field at point P?

	Electric potential	Electric field
A.	$\frac{2kQ}{R}$	$\frac{4kQ}{R^2}$
B.	$\frac{2kQ}{R}$	zero
C.	$\frac{kQ}{R}$	$\frac{4kQ}{R^2}$
D.	$\frac{kQ}{R}$	zero

30. A satellite of mass m is in orbit around a planet of radius R and mass M. The total energy of the satellite is $-\frac{GMm}{4R}$.

What is the radius of the orbit?

A. R

B. $\frac{4R}{3}$

C. $2R$

D. $\frac{8R}{3}$

31. In a direct current (dc) circuit a current of 4 A dissipates power P in a resistor. In an alternating current (ac) circuit the average power dissipated in the same resistor is also P. What is the value of the root mean square (rms) current in the ac circuit?

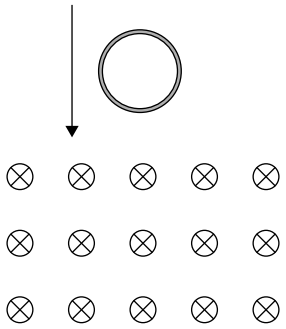
A. 2 A

B. $\frac{4}{\sqrt{2}}$ A

C. 4 A

D. $4\sqrt{2}$ A

32. A conducting ring is dropped from rest from above the ground. As it falls the ring passes through a region of uniform horizontal magnetic field. Air resistance is negligible.

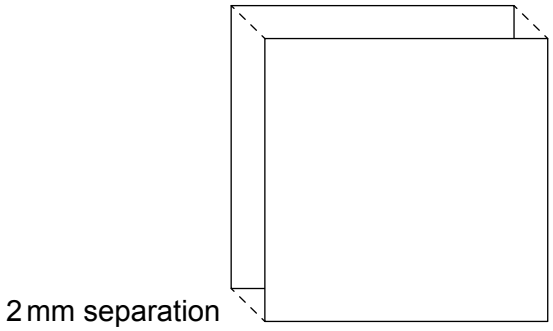


Which is correct about the acceleration a of the ring as it enters and as it leaves the region of magnetic field?

	Ring enters	Ring leaves
A.	$a > g$	$a > g$
B.	$a > g$	$a < g$
C.	$a < g$	$a > g$
D.	$a < g$	$a < g$

33. Which of the following parallel plate capacitors has the greatest capacitance?
(All plates are drawn to the same scale)

A.



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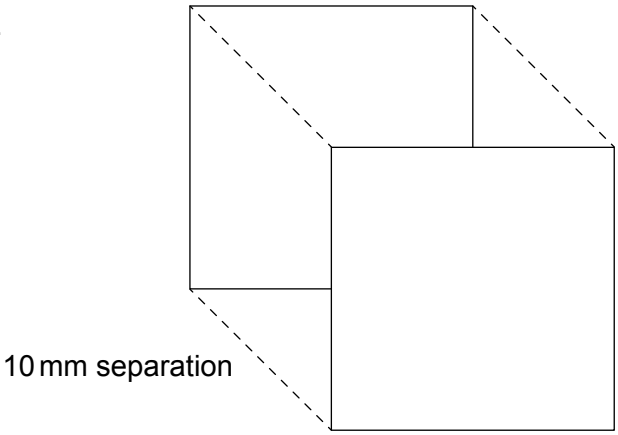
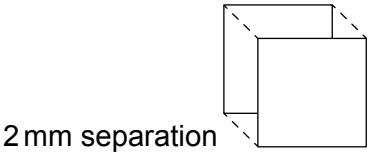


C.



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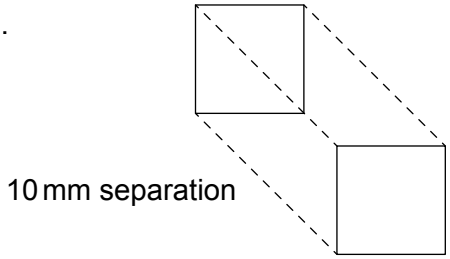
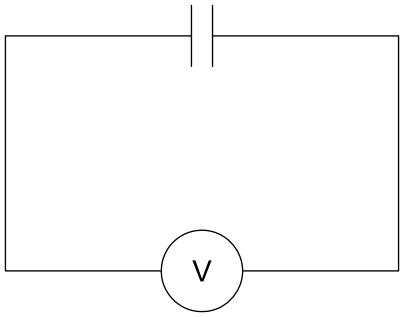


34. A fully charged capacitor is connected to an ideal voltmeter.



The capacitor is initially separated by air. Paper is inserted between the plates of the capacitor. What is the change in the charge on the capacitor plates and the change in the potential difference across the capacitor plates?

	Charge	Potential difference
A.	stays the same	stays the same
B.	stays the same	decreases
C.	increases	stays the same
D.	increases	decreases

35. A fully charged capacitor discharges through a resistor. The time constant of the circuit is τ. The initial energy stored in the capacitor is *E*. What is the energy stored in the capacitor at time $t = \tau$?

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

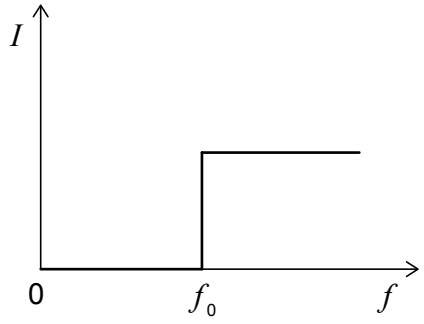
B. $\frac{E}{4}$

C. $\frac{E}{e}$

D. $\frac{E}{e^2}$

36. Light falls on a metallic surface whose threshold frequency is f_0. The number of photons incident per second is constant. Which graph correctly shows how the current I emitted from the surface depends on the frequency f of the incident light?

A.



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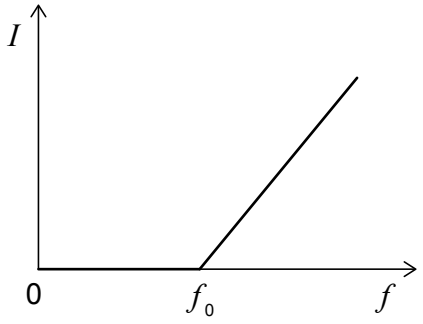
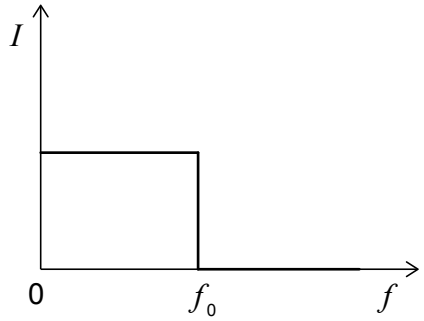
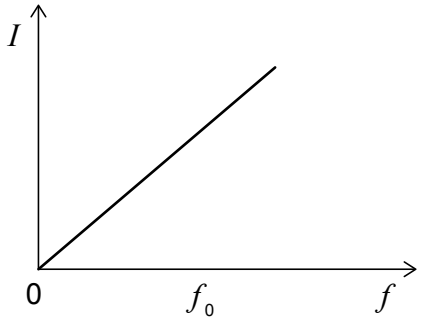


C.



D.



37. In the Bohr model for the hydrogen atom, what is $\frac{\text{angular momentum of first excited state}}{\text{angular momentum of ground state}}$?

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

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

C. 2

D. 4

38. In alpha decay, an alpha particle is emitted even though its kinetic energy is smaller than the height of the nuclear potential barrier. What makes alpha decay possible?

A. Conservation of energy does not apply to alpha particles.

B. The de Broglie wavelength of the alpha particle is larger than the nuclear radius.

C. The binding energy of alpha particles is greater than the binding energy of the nucleus.

D. The alpha particle wave function extends outside the nucleus.

39. In beta decay, the energy of the emitted beta particles is continuous. This is explained by the…

A. mass of alpha particles.

B. emission of gamma rays.

C. presence of energy levels in the nucleus.

D. existence of the neutrino.

40. The results obtained from Rutherford scattering experiments provide evidence for the existence of the nucleus in atoms. Deviations from Rutherford scattering…

I. provide evidence for the existence of the strong nuclear force.

II. allow for an estimation of the radius of the nucleus.

III. occur when alpha particles are incident at low energies.

Which statements are correct?

A. I and II only

B. I and III only

C. II and III only

D. I, II and III