

CBSE Class 12 Physics

Sample Paper – 1

Duration: 180 Minutes

Maximum Marks: 70

General Instructions

- This question paper contains **33 questions**. All questions are **compulsory**.
- The paper is divided into **five sections** – A, B, C, D and E.
- **Section A** (Q1–Q16) carries **1 mark** each: Q1–Q12 are multiple choice questions and Q13–Q16 are Assertion–Reason questions.
- **Section B** (Q17–Q21) carries **2 marks** each (Very Short Answer).
- **Section C** (Q22–Q28) carries **3 marks** each (Short Answer).
- **Section D** (Q29–Q30) carries **4 marks** each (case study based, with sub-parts).
- **Section E** (Q31–Q33) carries **5 marks** each (Long Answer).
- There is **no overall choice**, but an **internal choice** has been provided in some questions. Attempt only one of the alternatives in such questions.
- There is **no negative marking**. Use of a **calculator is not permitted**. You may use $c = 3 \times 10^8$ m/s, $h = 6.63 \times 10^{-34}$ Js, $e = 1.6 \times 10^{-19}$ C as required.

Section A (Q1–Q16) – 1 Mark Each

Q1. Two identical point charges separated by a distance r exert a force F on each other. If the separation is doubled while the charges are unchanged, the new force is:

- (A) $2F$
(B) $\frac{F}{4}$

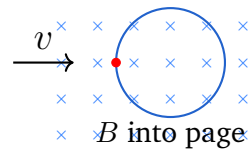


- (C) $\frac{F}{2}$
(D) $4F$

Q2. A wire of resistance R is stretched uniformly so that its length becomes twice the original. Assuming the volume stays constant, its new resistance is:

- (A) R
(B) $2R$
(C) $\frac{R}{2}$
(D) $4R$

Q3. A charged particle of charge q and mass m enters a uniform magnetic field B with speed v , perpendicular to the field, as shown. The radius of its circular path is:



- (A) $\frac{mv}{qB}$
(B) $\frac{qB}{mv}$
(C) $\frac{qvB}{m}$
(D) $\frac{mB}{qv}$

Q4. The magnetic flux linked with a coil changes from 2 Wb to 10 Wb in 4 s. The magnitude of the average induced emf is:

- (A) 8 V
(B) 12 V
(C) 2 V
(D) 0.5 V



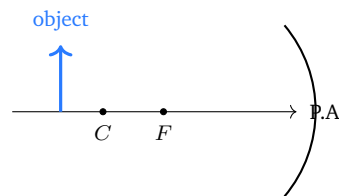
Q5. In a series LCR circuit, resonance occurs when:

- (A) $X_L = 2X_C$
- (B) $X_L = X_C$
- (C) $X_L = 0$
- (D) $R = X_L + X_C$

Q6. Which of the following electromagnetic waves has the *shortest* wavelength?

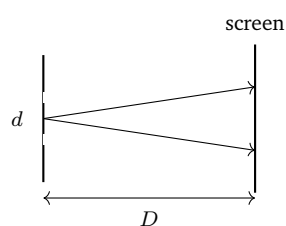
- (A) Microwaves
- (B) Infrared rays
- (C) Visible light
- (D) Gamma rays

Q7. An object is placed beyond the centre of curvature C of a concave mirror, as shown. The image formed is:



- (A) real, inverted and diminished
- (B) real, inverted and magnified
- (C) virtual, erect and magnified
- (D) virtual, erect and diminished

Q8. In Young's double-slit experiment, the fringe width β is given by ($D =$ slit-to-screen distance, $d =$ slit separation):



- (A) $\frac{\lambda d}{D}$
- (B) $\frac{d}{\lambda D}$
- (C) $\frac{\lambda D}{d}$
- (D) $\frac{D}{\lambda d}$

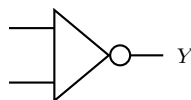
Q9. The work function of a metal is W . The threshold frequency ν_0 for photoelectric emission is:

- (A) hW
- (B) $\frac{W}{h}$
- (C) $\frac{h}{W}$
- (D) $\frac{W}{c}$

Q10. In the Bohr model of the hydrogen atom, the radius of the n -th orbit is proportional to:

- (A) n
- (B) $\frac{1}{n}$
- (C) $\frac{1}{n^2}$
- (D) n^2

Q11. The logic gate whose symbol is shown below, with the small bubble at the output, is a:



- (A) NOT gate
- (B) AND gate
- (C) OR gate
- (D) NOR gate



Q12. The capacitance of a parallel-plate capacitor is C . If the separation between the plates is halved and a dielectric of constant $K = 2$ is inserted to fill the gap, the new capacitance is:

- (A) C
- (B) $2C$
- (C) $4C$
- (D) $\frac{C}{4}$

Q13. Assertion (A): The electric field inside a charged hollow conductor is zero.

Reason (R): The net charge on an isolated conductor resides entirely on its outer surface.

- (A) Both A and R are true and R is the correct explanation of A.
- (B) Both A and R are true but R is *not* the correct explanation of A.
- (C) A is true but R is false.
- (D) A is false but R is true.

Q14. Assertion (A): The resistance of a metallic conductor increases with rise in temperature.

Reason (R): With rising temperature the rate of collision of free electrons with lattice ions increases.

- (A) Both A and R are true and R is the correct explanation of A.
- (B) Both A and R are true but R is *not* the correct explanation of A.
- (C) A is true but R is false.
- (D) A is false but R is true.

Q15. Assertion (A): A convex lens always forms a virtual image.

Reason (R): The focal length of a convex lens is taken as positive by the sign convention.

- (A) Both A and R are true and R is the correct explanation of A.



- (B) Both A and R are true but R is *not* the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

Q16. Assertion (A): The density of a nucleus is independent of its mass number A .

Reason (R): The nuclear radius is directly proportional to the mass number A .

- (A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is *not* the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

Section B (Q17–Q21) – 2 Marks Each

Q17. Two capacitors of capacitance $2\ \mu\text{F}$ and $3\ \mu\text{F}$ are connected in series. Find the equivalent capacitance of the combination. [2]

Q18. Define drift velocity. Write the relation between the current I through a conductor and the drift velocity v_d of its free electrons. [2]

Q19. The current in a coil changes from 0 to 2 A in 0.1 s and induces an emf of 20 V. Calculate the self-inductance of the coil. [2]

OR

A step-up transformer has 100 turns in the primary and 500 turns in the secondary. If the primary voltage is 220 V, find the secondary voltage (assume an ideal transformer).

Q20. Two thin lenses of power $+5\ \text{D}$ and $-2\ \text{D}$ are placed in contact. Find the power and the focal length of the combination. [2]

Q21. Calculate the de Broglie wavelength associated with an electron moving with a speed of $2 \times 10^6\ \text{m/s}$. (Take $m_e = 9.1 \times 10^{-31}\ \text{kg}$.) [2]

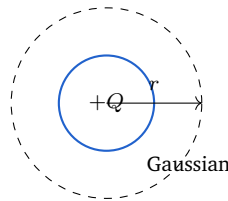


OR

The half-life of a radioactive sample is 20 minutes. What fraction of the original nuclei remains undecayed after 60 minutes?

Section C (Q22–Q28) – 3 Marks Each

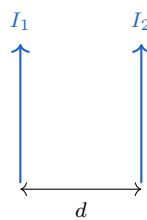
Q22. Using Gauss’s law, derive an expression for the electric field at a point at distance r ($r > R$) from the centre of a uniformly charged conducting sphere of radius R carrying charge Q .



[3]

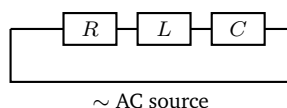
Q23. State the balance condition of a Wheatstone bridge. In a metre bridge, the null point is obtained at 40 cm from one end when the known resistance is 6Ω . Find the unknown resistance. [3]

Q24. Two long straight parallel wires carry currents I_1 and I_2 in the same direction, separated by a distance d . Derive the expression for the force per unit length between them and state whether it is attractive or repulsive.



[3]

Q25. A series LCR circuit has $R = 30 \Omega$, $X_L = 50 \Omega$ and $X_C = 10 \Omega$, connected to an AC source. Find the impedance of the circuit and the phase angle between the current and the voltage.

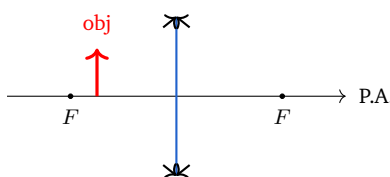


[3]

OR

Define the quality factor of a series resonant circuit. A circuit has $L = 2 \text{ H}$, $C = 8 \mu\text{F}$ and $R = 10 \Omega$. Find its resonant angular frequency ω_0 .

- Q26.** Draw a ray diagram for the image formed by a convex lens when the object is placed between F and $2F$. Using the lens formula, find the image distance when an object is placed 15 cm in front of a convex lens of focal length 10 cm.



[3]

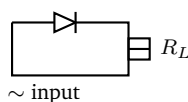
OR

State the conditions for total internal reflection. The critical angle for a glass-air interface is 42° . Find the refractive index of the glass. (Take $\sin 42^\circ = 0.67$.)

- Q27.** Light of frequency $8 \times 10^{14} \text{ Hz}$ is incident on a metal of work function 2 eV. Using Einstein's photoelectric equation, find the maximum kinetic energy of the emitted photoelectrons (in eV). (Take $h = 6.63 \times 10^{-34} \text{ Js}$, $1 \text{ eV} = 1.6 \times 10^{-19} \text{ J}$.)

[3]

- Q28.** With the help of a labelled circuit diagram, explain the working of a p-n junction diode as a half-wave rectifier. Draw the output waveform.



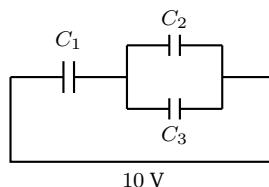
[3]

Section D (Q29–Q30) – 4 Marks Each (Case Study)



Q29. Case Study – Combination of Capacitors.

A student connects three capacitors $C_1 = 2 \mu\text{F}$, $C_2 = 3 \mu\text{F}$ and $C_3 = 6 \mu\text{F}$. First C_2 and C_3 are joined in parallel, and this parallel combination is then joined in series with C_1 across a 10 V battery, as shown.

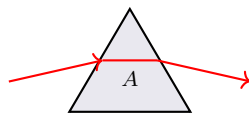


Based on the above, answer the following:

- (i) Find the equivalent capacitance of C_2 and C_3 in parallel. (1)
- (ii) Find the total equivalent capacitance of the circuit. (1)
- (iii) Find the total charge drawn from the battery and the energy stored. (2)

Q30. Case Study – Refraction Through a Prism.

A ray of light passes through a glass prism of refracting angle $A = 60^\circ$. At minimum deviation the ray passes symmetrically through the prism, and the angle of minimum deviation is measured to be $\delta_m = 40^\circ$.



Based on the above, answer the following:

- (i) Write the prism formula relating μ , A and δ_m . (1)
- (ii) Find the angle of incidence i at minimum deviation. (1)
- (iii) Calculate the refractive index μ of the prism material. (Take $\sin 50^\circ = 0.766$, $\sin 30^\circ = 0.5$.) (2)

Section E (Q31–Q33) – 5 Marks Each

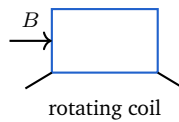
Q31. (a) Derive an expression for the electric potential at a point on the axial line of an electric dipole at distance r from its centre.

(b) An electric dipole of dipole moment $p = 4 \times 10^{-9} \text{ C m}$ is placed in a uniform electric field of $5 \times 10^4 \text{ N/C}$ at an angle of 30° to the field. Find the torque acting on it. [5]

OR

- (a) Derive an expression for the energy stored in a charged parallel-plate capacitor.
- (b) A $4 \mu\text{F}$ capacitor is charged to 200 V. Find the energy stored in it.

- Q32.** (a) With the help of a labelled diagram, explain the principle and working of an AC generator, and write the expression for the instantaneous emf produced.
- (b) A coil of 50 turns and area 0.1 m^2 rotates at an angular speed such that the peak emf is 100 V in a field of 0.2 T. Find the angular speed ω .

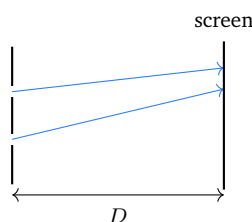


[5]

OR

- (a) Derive the expression for the impedance of a series LCR circuit using a phasor diagram.
- (b) Define resonance and write the expression for the resonant frequency f_0 .

- Q33.** (a) In Young's double-slit experiment, derive the expression for the fringe width β of the interference pattern.
- (b) In such an experiment, the slits are 0.5 mm apart and the screen is 1 m away. If the wavelength of light used is 600 nm, find the fringe width.



[5]

OR



- (a) Draw a labelled ray diagram of an astronomical telescope in normal adjustment and define its magnifying power.
- (b) The objective and eyepiece of a telescope have focal lengths 100 cm and 2 cm respectively. Find its magnifying power in normal adjustment.



Detailed Solutions

Q1.

Solution

Concept — Coulomb's law: The force between two point charges is inversely proportional to the square of the separation, $F \propto \frac{1}{r^2}$.

Step 1 — Write the original force:

$$F = \frac{1}{4\pi\epsilon_0} \frac{q^2}{r^2}$$

Step 2 — Double the separation: Replace r by $2r$:

$$\begin{aligned} F' &= \frac{1}{4\pi\epsilon_0} \frac{q^2}{(2r)^2} \\ &= \frac{1}{4\pi\epsilon_0} \frac{q^2}{4r^2} \\ &= \frac{F}{4} \end{aligned}$$

Why other options are wrong: (A) $2F$ and (D) $4F$ assume force grows with distance; (C) $\frac{F}{2}$ uses a $1/r$ dependence instead of $1/r^2$.

Final Answer: New force = $\frac{F}{4} \Rightarrow$ **B**

Answer: (B) [Go Back to Q1](#)

Q2.

Solution

Concept — Resistance of a stretched wire: At constant volume, $R \propto \ell^2$, because stretching to length ℓ reduces the area so that $A = V/\ell$.

Step 1 — Express resistance:

$$R = \rho \frac{\ell}{A} = \rho \frac{\ell}{V/\ell} = \rho \frac{\ell^2}{V}$$

Step 2 — Double the length: Replace ℓ by 2ℓ :

$$R' = \rho \frac{(2\ell)^2}{V} = \rho \frac{4\ell^2}{V}$$



$$= 4R.$$

Why other options are wrong: (A) R ignores the area change; (B) $2R$ scales linearly; (C) $\frac{R}{2}$ has the dependence inverted.

Final Answer: New resistance = $4R \Rightarrow$ **D**

Answer: (D) [Go Back to Q2](#)

Q3.

Solution

Concept — Circular motion in a magnetic field: The magnetic force supplies the centripetal force, so $qvB = \frac{mv^2}{r}$.

Step 1 — Equate the forces:

$$qvB = \frac{mv^2}{r}.$$

Step 2 — Solve for r :

$$r = \frac{mv^2}{qvB} = \frac{mv}{qB}.$$

Why other options are wrong: (B) inverts the expression; (C) and (D) misplace v and B in the ratio.

Final Answer: Radius $r = \frac{mv}{qB} \Rightarrow$ **A**

Answer: (A) [Go Back to Q3](#)

Q4.

Solution

Concept — Faraday's law: The magnitude of the average induced emf is $|\varepsilon| = \frac{\Delta\phi}{\Delta t}$.

Step 1 — Change in flux:

$$\Delta\phi = 10 - 2 = 8 \text{ Wb.}$$

Step 2 — Divide by the time interval:

$$|\varepsilon| = \frac{8}{4}.$$



$$= 2 \text{ V.}$$

Why other options are wrong: (A) 8 V forgets to divide by time; (B) 12 V adds the fluxes; (D) 0.5 V inverts the ratio.

Final Answer: Induced emf = 2 V \Rightarrow C

Answer: (C) [Go Back to Q4](#)

Q5.

Solution

Concept — Series resonance: At resonance the inductive and capacitive reactances cancel, so the net reactance is zero and the impedance is purely resistive.

Step 1 — Condition for zero net reactance:

$$X_L - X_C = 0.$$

$$X_L = X_C.$$

Step 2 — Consequence: The impedance is then minimum, $Z = R$, and the current is maximum.

Why other options are wrong: (A) $X_L = 2X_C$ leaves a net reactance; (C) $X_L = 0$ is not required; (D) is dimensionally the wrong condition.

Final Answer: Resonance at $X_L = X_C \Rightarrow$ B

Answer: (B) [Go Back to Q5](#)

Q6.

Solution

Concept — Electromagnetic spectrum: In order of decreasing wavelength: radio > microwave > infrared > visible > ultraviolet > X-rays > gamma rays.

Step 1 — Compare the given options: Among microwaves, infrared, visible and gamma rays, gamma rays sit at the far short-wavelength end.

Step 2 — Conclusion: Gamma rays have the shortest wavelength (and the highest frequency).

Why other options are wrong: (A) microwaves and (B) infrared have far longer wavelengths; (C) visible light is longer than gamma rays.



Final Answer: Gamma rays \Rightarrow

Answer: (D) [Go Back to Q6](#)

Q7.

Solution

Concept — Concave mirror imaging: For an object beyond C , a concave mirror forms an image between F and C that is real, inverted and diminished.

Step 1 — Locate the object: The object is beyond the centre of curvature C .

Step 2 — Apply the standard result: Reflected rays converge between F and C , so the image is real and inverted, and smaller than the object.

Why other options are wrong: (B) magnified real image needs the object between C and F ; (C) and (D) virtual images need the object within F .

Final Answer: Real, inverted and diminished \Rightarrow

Answer: (A) [Go Back to Q7](#)

Q8.

Solution

Concept — Fringe width in YDSE: The spacing between consecutive bright (or dark) fringes is $\beta = \frac{\lambda D}{d}$.

Step 1 — Recall the derivation result: Path difference for the n -th bright fringe gives position $y_n = \frac{n\lambda D}{d}$.

Step 2 — Fringe width: Subtract consecutive positions:

$$\beta = y_{n+1} - y_n = \frac{\lambda D}{d}.$$

Why other options are wrong: (A) and (B) invert D and d ; (D) inverts λ .

Final Answer: $\beta = \frac{\lambda D}{d} \Rightarrow$

Answer: (C) [Go Back to Q8](#)



Q9.

Solution

Concept — Threshold frequency: Emission just begins when the photon energy equals the work function, $h\nu_0 = W$.

Step 1 — Write the condition:

$$h\nu_0 = W.$$

Step 2 — Solve for ν_0 :

$$\nu_0 = \frac{W}{h}.$$

Why other options are wrong: (A) hW has wrong dimensions; (C) $\frac{h}{W}$ inverts the ratio; (D) uses c instead of h .

Final Answer: $\nu_0 = \frac{W}{h} \Rightarrow$ **B**

Answer: (B) [Go Back to Q9](#)

Q10.

Solution

Concept — Bohr orbit radius: In the Bohr model, $r_n = \frac{n^2 h^2 \epsilon_0}{\pi m e^2}$, so $r_n \propto n^2$.

Step 1 — Recall the quantisation: Angular momentum $mvr = \frac{nh}{2\pi}$ combined with the Coulomb force balance gives $r_n \propto n^2$.

Step 2 — Conclusion: The radius grows as the square of the principal quantum number.

Why other options are wrong: (A) linear and (B),(C) inverse dependences contradict the derivation.

Final Answer: $r_n \propto n^2 \Rightarrow$ **D**

Answer: (D) [Go Back to Q10](#)



Q11.

Solution

Concept — Logic gate symbols: A triangular buffer body with a small bubble at the output followed by two inputs at a curved-back OR body denotes a NOR gate; the bubble represents inversion of the OR output.

Step 1 — Read the symbol: Two inputs feed an OR-type body, and the output carries an inversion bubble.

Step 2 — Identify the gate: OR followed by inversion is the NOR gate, with output $Y = \overline{A + B}$.

Why other options are wrong: (A) NOT has a single input; (B) AND has no bubble and a flat back; (C) OR lacks the output bubble.

Final Answer: NOR gate \Rightarrow D

Answer: (D) [Go Back to Q11](#)

Q12.

Solution

Concept — Parallel-plate capacitance: $C = \frac{K\varepsilon_0 A}{d}$; capacitance rises with K and falls with separation d .

Step 1 — Original capacitance:

$$C = \frac{\varepsilon_0 A}{d}$$

Step 2 — Halve d and insert $K = 2$:

$$\begin{aligned} C' &= \frac{2\varepsilon_0 A}{d/2} \\ &= \frac{2\varepsilon_0 A \cdot 2}{d} \\ &= 4 \frac{\varepsilon_0 A}{d} = 4C. \end{aligned}$$

Why other options are wrong: (A) C ignores both changes; (B) $2C$ counts only one factor; (D) $\frac{C}{4}$ has the effect reversed.

Final Answer: New capacitance $= 4C \Rightarrow$ C

Answer: (C) [Go Back to Q12](#)



Q13.

Solution

Concept — Assertion–Reason on conductors: Assess each statement, then decide whether R explains A.

Step 1 — Assertion: The electric field inside the material and cavity of a charged hollow conductor is zero. So A is **true**.

Step 2 — Reason: On an isolated charged conductor, all excess charge resides on the outer surface. So R is **true**.

Step 3 — Does R explain A? The charge sitting on the outer surface is exactly why no field penetrates the interior, so R correctly explains A.

Why other options are wrong: (B) denies the link that exists; (C),(D) misjudge a truth value.

Final Answer: Both true, R explains A \Rightarrow

[Go Back to Q13](#)

Q14.

Solution

Concept — Temperature dependence of resistance: For metals, resistance rises with temperature because electron-lattice collisions become more frequent.

Step 1 — Assertion: Metallic resistance increases with temperature. So A is **true**.

Step 2 — Reason: Higher temperature increases lattice vibration, raising the collision rate and reducing the relaxation time τ . So R is **true**.

Step 3 — Does R explain A? Since $R \propto \frac{1}{\tau}$, a shorter τ raises resistance, so R is the correct explanation of A.

Why other options are wrong: (B) denies a real causal link; (C),(D) misjudge a truth value.

Final Answer: Both true, R explains A \Rightarrow

[Go Back to Q14](#)



Q15.

Solution

Concept — Convex lens imaging: A convex lens forms a real image for most object positions; only when the object is within the focus does it form a virtual image.

Step 1 — Assertion: "A convex lens always forms a virtual image" is **false**; for an object beyond F the image is real.

Step 2 — Reason: By the sign convention, the focal length of a convex lens is positive. This statement is **true**.

Step 3 — Combine: A is false and R is true.

Why other options are wrong: (A),(B) require A true; (C) requires R false.

Final Answer: A false, R true \Rightarrow D

Answer: (D) [Go Back to Q15](#)

Q16.

Solution

Concept — Nuclear density: Since $R = R_0 A^{1/3}$, the nuclear volume is proportional to A , so density ($\propto A/\text{volume}$) is constant.

Step 1 — Assertion: Nuclear density is the same for all nuclei, independent of A . So A is **true**.

Step 2 — Reason: The stated relation " $R \propto A$ " is **false**; the correct relation is $R \propto A^{1/3}$.

Step 3 — Combine: A is true but R is false.

Why other options are wrong: (A),(B) require R true; (D) requires A false.

Final Answer: A true, R false \Rightarrow C

Answer: (C) [Go Back to Q16](#)



Q17.

Solution

Concept — Capacitors in series: The reciprocal of the equivalent capacitance is the sum of the reciprocals, $\frac{1}{C_s} = \frac{1}{C_1} + \frac{1}{C_2}$.

Step 1 — Add the reciprocals:

$$\begin{aligned}\frac{1}{C_s} &= \frac{1}{2} + \frac{1}{3} \\ &= \frac{3+2}{6} = \frac{5}{6}\end{aligned}$$

Step 2 — Invert:

$$C_s = \frac{6}{5} = 1.2 \mu\text{F}.$$

Final Answer: Equivalent capacitance = 1.2 μF . [Go Back to Q17](#)

Q18.

Solution

Concept — Drift velocity: It is the small average velocity acquired by the free electrons of a conductor along the direction opposite to the applied electric field.

Step 1 — Definition: Drift velocity v_d is the net average velocity of free electrons under an applied field, superposed on their random thermal motion.

Step 2 — Current relation: If n is the free-electron density, A the cross-section and e the electronic charge,

$$I = n A e v_d.$$

Final Answer: $I = n A e v_d$, where v_d is the drift velocity. [Go Back to Q18](#)

Q19.

Solution

Concept — Self-induced emf: The back-emf of a coil is $\varepsilon = L \frac{dI}{dt}$.

Step 1 — Rate of change of current:

$$\frac{dI}{dt} = \frac{2 - 0}{0.1} = 20 \text{ A/s}.$$



Step 2 — Solve for L :

$$L = \frac{\varepsilon}{dI/dt} = \frac{20}{20} \\ = 1 \text{ H.}$$

Final Answer: Self-inductance $L = 1 \text{ H}$.

OR — Transformer secondary voltage:

Step 1 — Turns ratio: $\frac{V_s}{V_p} = \frac{N_s}{N_p}$.

Step 2 — Substitute:

$$V_s = 220 \times \frac{500}{100} = 220 \times 5 = 1100 \text{ V.}$$

Final Answer (OR): Secondary voltage = 1100 V. [Go Back to Q19](#)

Q20.

Solution

Concept — Lenses in contact: Powers add directly, $P = P_1 + P_2$, and $f = \frac{1}{P}$ (with P in dioptres and f in metres).

Step 1 — Add the powers:

$$P = (+5) + (-2) = +3 \text{ D.}$$

Step 2 — Find the focal length:

$$f = \frac{1}{P} = \frac{1}{3} \text{ m} = +0.33 \text{ m} = +33.3 \text{ cm.}$$

Final Answer: Power = +3 D; focal length $\approx +33.3 \text{ cm}$ (converging). [Go Back to Q20](#)

Q21.

Solution

Concept — de Broglie wavelength: $\lambda = \frac{h}{mv}$.

Step 1 — Substitute the values:

$$\lambda = \frac{6.63 \times 10^{-34}}{(9.1 \times 10^{-31})(2 \times 10^6)}.$$



Step 2 — Denominator:

$$(9.1 \times 10^{-31})(2 \times 10^6) = 1.82 \times 10^{-24}.$$

Step 3 — Divide:

$$\lambda = \frac{6.63 \times 10^{-34}}{1.82 \times 10^{-24}} = 3.64 \times 10^{-10} \text{ m}.$$

Final Answer: $\lambda \approx 3.64 \times 10^{-10} \text{ m} = 3.64 \text{ \AA}$.

OR — Fraction undecayed after 60 min:

Step 1 — Number of half-lives: $\frac{60}{20} = 3$.

Step 2 — Remaining fraction:

$$\left(\frac{1}{2}\right)^3 = \frac{1}{8}.$$

Final Answer (OR): A fraction $\frac{1}{8}$ remains undecayed. [Go Back to Q21](#)

Q22.

Solution

Concept — Gauss's law: The net flux through a closed surface equals $\frac{q_{\text{enc}}}{\epsilon_0}$.

Step 1 — Choose a Gaussian surface: Take a concentric sphere of radius $r > R$. By symmetry \vec{E} is radial and constant in magnitude over it.

Step 2 — Flux through it:

$$\oint \vec{E} \cdot d\vec{A} = E (4\pi r^2).$$

Step 3 — Apply Gauss's law: The full charge Q is enclosed:

$$E (4\pi r^2) = \frac{Q}{\epsilon_0}.$$

Step 4 — Solve for E :

$$E = \frac{1}{4\pi\epsilon_0} \frac{Q}{r^2}.$$

Final Answer: $E = \frac{1}{4\pi\epsilon_0} \frac{Q}{r^2}$, the same as that of a point charge Q at the centre.

[Go Back to Q22](#)



Q23.

Solution

Concept — Metre bridge (balanced Wheatstone bridge): At balance $\frac{P}{Q} = \frac{R}{S}$;
on a metre bridge this becomes $\frac{R}{S} = \frac{\ell}{100 - \ell}$.

Step 1 — Balance condition: With the known resistance $S = 6 \Omega$ and null point $\ell = 40$ cm,

$$\frac{R}{6} = \frac{40}{100 - 40}.$$

Step 2 — Simplify the ratio:

$$\frac{R}{6} = \frac{40}{60} = \frac{2}{3}.$$

Step 3 — Solve for R :

$$R = 6 \times \frac{2}{3} = 4 \Omega.$$

Final Answer: Unknown resistance = 4Ω . [Go Back to Q23](#)

Q24.

Solution

Concept — Force between parallel currents: One wire's field acts on the other's current; parallel currents attract.

Step 1 — Field of wire 1 at wire 2:

$$B_1 = \frac{\mu_0 I_1}{2\pi d}.$$

Step 2 — Force on length L of wire 2:

$$F = B_1 I_2 L = \frac{\mu_0 I_1 I_2 L}{2\pi d}.$$

Step 3 — Force per unit length:

$$\frac{F}{L} = \frac{\mu_0 I_1 I_2}{2\pi d}.$$

Step 4 — Direction: With currents in the same direction the wires are pulled together, so the force is *attractive*.



Final Answer: $\frac{F}{L} = \frac{\mu_0 I_1 I_2}{2\pi d}$, attractive. [Go Back to Q24](#)

Q25.

Solution

Concept — Impedance of series LCR: $Z = \sqrt{R^2 + (X_L - X_C)^2}$ and $\tan \varphi = \frac{X_L - X_C}{R}$.

Step 1 — Net reactance:

$$X_L - X_C = 50 - 10 = 40 \Omega.$$

Step 2 — Impedance:

$$Z = \sqrt{30^2 + 40^2} = \sqrt{900 + 1600} = \sqrt{2500} = 50 \Omega.$$

Step 3 — Phase angle:

$$\tan \varphi = \frac{40}{30} = \frac{4}{3}.$$

$$\varphi = \tan^{-1}\left(\frac{4}{3}\right) \approx 53^\circ \text{ (voltage leads current).}$$

Final Answer: $Z = 50 \Omega$, $\varphi \approx 53^\circ$.

OR — Quality factor and ω_0 :

Step 1 — Definition: The quality factor $Q = \frac{\omega_0 L}{R} = \frac{1}{R} \sqrt{\frac{L}{C}}$ measures the sharpness of resonance.

Step 2 — Resonant angular frequency:

$$\begin{aligned} \omega_0 &= \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{(2)(8 \times 10^{-6})}} \\ &= \frac{1}{\sqrt{1.6 \times 10^{-5}}} = \frac{1}{4 \times 10^{-3}} = 250 \text{ rad/s.} \end{aligned}$$

Final Answer (OR): $\omega_0 = 250 \text{ rad/s}$. [Go Back to Q25](#)



Q26.

Solution

Concept — Lens formula: $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$, with sign convention (u negative for a real object).

Step 1 — Assign values: $u = -15$ cm, $f = +10$ cm.

Step 2 — Substitute:

$$\frac{1}{v} = \frac{1}{f} + \frac{1}{u} = \frac{1}{10} + \frac{1}{-15}.$$

Step 3 — Simplify:

$$\frac{1}{v} = \frac{3}{30} - \frac{2}{30} = \frac{1}{30}.$$

$$v = +30 \text{ cm.}$$

The image is real, inverted and magnified, formed beyond $2F$ on the far side.

Final Answer: $v = +30$ cm (real, inverted, magnified).

OR — Total internal reflection:

Step 1 — Conditions: (i) light must travel from a denser to a rarer medium; (ii) the angle of incidence must exceed the critical angle θ_c .

Step 2 — Refractive index from θ_c :

$$\mu = \frac{1}{\sin \theta_c} = \frac{1}{\sin 42^\circ} = \frac{1}{0.67} \approx 1.49.$$

Final Answer (OR): $\mu \approx 1.49$. [Go Back to Q26](#)

Q27.

Solution

Concept — Einstein's photoelectric equation: $K_{\max} = h\nu - W$.

Step 1 — Photon energy in joules:

$$h\nu = (6.63 \times 10^{-34})(8 \times 10^{14}).$$

$$= 5.30 \times 10^{-19} \text{ J.}$$

Step 2 — Convert to eV:

$$h\nu = \frac{5.30 \times 10^{-19}}{1.6 \times 10^{-19}} = 3.31 \text{ eV.}$$



Step 3 — Subtract the work function:

$$K_{\max} = 3.31 - 2.0 = 1.31 \text{ eV.}$$

Final Answer: $K_{\max} \approx 1.31 \text{ eV}$. [Go Back to Q27](#)

Q28.

Solution

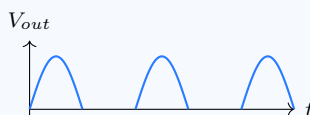
Concept — Half-wave rectifier: A single p-n junction diode conducts only when forward biased, so it passes just one half of each AC cycle.

Step 1 — Circuit: The AC input is applied through the diode in series with the load R_L (as drawn).

Step 2 — Positive half-cycle: The diode is forward biased, conducts, and current flows through R_L , giving an output voltage.

Step 3 — Negative half-cycle: The diode is reverse biased, does not conduct, so the output is zero.

Step 4 — Output waveform: A series of positive half-sine pulses with gaps where the negative halves are blocked.



Final Answer: The diode rectifies AC to a pulsating DC output present only during forward-biased (positive) half-cycles. [Go Back to Q28](#)

Q29.

Solution

Concept — Series/parallel capacitors and energy: Parallel capacitances add; series follow reciprocal addition; energy $U = \frac{1}{2}CV^2$ and charge $Q = CV$.

(i) C_2 and C_3 in parallel:

$$C_{23} = C_2 + C_3 = 3 + 6 = 9 \mu\text{F.}$$



(ii) Total (series of C_1 with C_{23}):

$$\frac{1}{C_{eq}} = \frac{1}{2} + \frac{1}{9} = \frac{9+2}{18} = \frac{11}{18}$$

$$C_{eq} = \frac{18}{11} \approx 1.64 \mu\text{F}$$

(iii) Charge and energy at $V = 10 \text{ V}$:

$$Q = C_{eq}V = 1.64 \times 10^{-6} \times 10 = 1.64 \times 10^{-5} \text{ C}$$

$$U = \frac{1}{2}C_{eq}V^2 = \frac{1}{2}(1.64 \times 10^{-6})(10)^2$$

$$= \frac{1}{2}(1.64 \times 10^{-6})(100) = 8.2 \times 10^{-5} \text{ J}$$

Final Answer: $C_{23} = 9 \mu\text{F}$; $C_{eq} \approx 1.64 \mu\text{F}$; $Q \approx 1.64 \times 10^{-5} \text{ C}$; $U \approx 8.2 \times 10^{-5} \text{ J}$. **Go Back to Q29**

Q30.

Solution

Concept — Prism at minimum deviation: The refractive index is $\mu = \frac{\sin\left(\frac{A + \delta_m}{2}\right)}{\sin\left(\frac{A}{2}\right)}$, and the ray passes symmetrically.

(i) Prism formula:

$$\mu = \frac{\sin\left(\frac{A + \delta_m}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

(ii) Angle of incidence: At minimum deviation, $i = \frac{A + \delta_m}{2}$:

$$i = \frac{60^\circ + 40^\circ}{2} = \frac{100^\circ}{2} = 50^\circ$$

(iii) Refractive index:

$$\mu = \frac{\sin 50^\circ}{\sin 30^\circ} = \frac{0.766}{0.5}$$

$$= 1.532$$

Final Answer: $i = 50^\circ$; $\mu \approx 1.53$. **Go Back to Q30**



Q31.

Solution

Concept — Dipole potential and torque: On the axis, the potentials of the $+q$ and $-q$ charges partly cancel, leaving a $1/r^2$ term; torque is $\tau = pE \sin \theta$.

(a) Axial potential: For a dipole of moment $p = q(2a)$, the potential at axial distance r ($r \gg a$) is

$$\begin{aligned} V &= \frac{1}{4\pi\epsilon_0} \frac{q}{r-a} - \frac{1}{4\pi\epsilon_0} \frac{q}{r+a} \\ &= \frac{q}{4\pi\epsilon_0} \cdot \frac{(r+a) - (r-a)}{(r-a)(r+a)} \\ &= \frac{q}{4\pi\epsilon_0} \cdot \frac{2a}{r^2 - a^2} \end{aligned}$$

For $r \gg a$, $r^2 - a^2 \approx r^2$, so

$$V = \frac{1}{4\pi\epsilon_0} \frac{p}{r^2}$$

(b) Torque:

$$\begin{aligned} \tau &= pE \sin \theta = (4 \times 10^{-9})(5 \times 10^4) \sin 30^\circ \\ &= (4 \times 10^{-9})(5 \times 10^4)(0.5) \\ &= 1 \times 10^{-4} \text{ N m} \end{aligned}$$

Final Answer: $V = \frac{1}{4\pi\epsilon_0} \frac{p}{r^2}$; $\tau = 1 \times 10^{-4} \text{ N m}$.

OR — Energy in a capacitor:

(a) Work done to move charge dq across potential $V = q/C$ is $dW = \frac{q}{C} dq$; integrating from 0 to Q ,

$$U = \int_0^Q \frac{q}{C} dq = \frac{Q^2}{2C} = \frac{1}{2} CV^2$$

(b) With $C = 4 \mu\text{F}$, $V = 200 \text{ V}$,

$$U = \frac{1}{2}(4 \times 10^{-6})(200)^2 = \frac{1}{2}(4 \times 10^{-6})(4 \times 10^4) = 0.08 \text{ J}$$

Final Answer (OR): $U = \frac{1}{2} CV^2 = 0.08 \text{ J}$. **Go Back to Q31**



Q32.

Solution

Concept — AC generator: A coil rotating in a magnetic field has a continuously changing flux, inducing a sinusoidal emf by Faraday's law.

(a) Principle and working: As the coil of N turns and area A rotates with angular speed ω in field B , the flux is $\phi = NBA \cos \omega t$. By Faraday's law,

$$\varepsilon = -\frac{d\phi}{dt} = NBA\omega \sin \omega t.$$

The peak emf is $\varepsilon_0 = NBA\omega$, so $\varepsilon = \varepsilon_0 \sin \omega t$.

(b) Angular speed: Given $\varepsilon_0 = 100$ V, $N = 50$, $A = 0.1$ m², $B = 0.2$ T:

$$\begin{aligned}\omega &= \frac{\varepsilon_0}{NBA} = \frac{100}{(50)(0.2)(0.1)} \\ &= \frac{100}{1} = 100 \text{ rad/s}.\end{aligned}$$

Final Answer: $\varepsilon = NBA\omega \sin \omega t$; $\omega = 100$ rad/s.

OR — Impedance of series LCR (phasor method):

(a) The voltage phasors are V_R (in phase with I), V_L (leading by 90°) and V_C (lagging by 90°). Their resultant gives

$$V = \sqrt{V_R^2 + (V_L - V_C)^2} = I\sqrt{R^2 + (X_L - X_C)^2}.$$

Hence the impedance is

$$Z = \sqrt{R^2 + (X_L - X_C)^2}.$$

(b) Resonance occurs when $X_L = X_C$, giving

$$f_0 = \frac{1}{2\pi\sqrt{LC}}.$$

Final Answer (OR): $Z = \sqrt{R^2 + (X_L - X_C)^2}$; $f_0 = \frac{1}{2\pi\sqrt{LC}}$. **Go Back to Q32**



Q33.

Solution

Concept — Interference fringe width: Bright fringes occur where the path difference is an integer multiple of λ ; consecutive bright fringes are separated by $\beta = \frac{\lambda D}{d}$.

(a) Derivation: For slit separation d and screen distance D , the path difference at a point y on the screen is $\Delta = \frac{yd}{D}$. Bright fringes need $\Delta = n\lambda$, so

$$y_n = \frac{n\lambda D}{d}.$$

The fringe width is the gap between consecutive bright fringes:

$$\beta = y_{n+1} - y_n = \frac{\lambda D}{d}.$$

(b) Numerical: $d = 0.5 \text{ mm} = 0.5 \times 10^{-3} \text{ m}$, $D = 1 \text{ m}$, $\lambda = 600 \text{ nm} = 6 \times 10^{-7} \text{ m}$:

$$\begin{aligned} \beta &= \frac{(6 \times 10^{-7})(1)}{0.5 \times 10^{-3}} \\ &= \frac{6 \times 10^{-7}}{5 \times 10^{-4}} = 1.2 \times 10^{-3} \text{ m} = 1.2 \text{ mm}. \end{aligned}$$

Final Answer: $\beta = \frac{\lambda D}{d} = 1.2 \text{ mm}$.

OR — Astronomical telescope:

(a) In normal adjustment the final image is at infinity; the magnifying power is $m = \frac{f_o}{f_e}$, the ratio of objective to eyepiece focal lengths.

(b) With $f_o = 100 \text{ cm}$ and $f_e = 2 \text{ cm}$,

$$m = \frac{100}{2} = 50.$$

Final Answer (OR): $m = \frac{f_o}{f_e} = 50$. **Go Back to Q33**



Answer Key – Section A (Q1–Q16)

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	B	2	D	3	A	4	C	5	B
6	D	7	A	8	C	9	B	10	D
11	D	12	C	13	A	14	A	15	D
16	C								

Sections B–E are descriptive; refer to the Detailed Solutions above for full model answers and step marking.

