JEE Main Physics Sample Paper – 8

Duration: 60 Minutes | Maximum Marks: 100

Instructions

- **Section A** contains 20 Multiple Choice Questions (Q1–Q20). Each question has four options with only one correct answer. Correct answer: **+4** marks; Wrong answer: $-$**1** mark; Unattempted: **0** marks.
- **Section B** contains 10 Numerical Value Questions (Q21–Q30). Attempt **any 5** questions. Correct answer: **+4** marks; Wrong or unattempted: **0** marks (no negative marking).
- The syllabus is based on Class 11 & 12 NCERT Physics as per the JEE Main official syllabus.
- Use of personal calculators, log tables, and electronic devices is strictly prohibited.
- A simple on-screen virtual calculator is provided in the CBT interface.
- Rough work may be done in the space provided within the question paper. Do not write anything on the Answer Sheet that is not required.

SECTION A (Single Correct MCQ) Q1 – Q20 [+4 / $-$1]

Q1. A ball is thrown vertically upward from the ground with an initial speed $u = 20$ m/s ($g = 10$ m/s^2). The total time of flight (from launch until it returns to the ground) is:

(A) 1 s

(B) 2 s

(C) 3 s

(D) 4 s

Q2. A block of mass $m = 10$ kg rests on a horizontal surface. The coefficient of static friction between the block and the surface is $\mu_s = 0.4$ ($g = 10$ m/s^2). The maximum static friction force that can act on the block is:

(A) 40 N

(B) 20 N

(C) 60 N

(D) 100 N

Q3. A ball of mass m moving with velocity v collides head-on elastically with an identical stationary ball (mass m). After the collision, the kinetic energy of the initially stationary ball is:

(A) 0

(B) $\frac{1}{2}mv^2$

(C) $\frac{1}{4}mv^2$

(D) mv^2

Q4. A solid sphere and a hollow sphere, both of the same mass M and the same radius R, are compared. The ratio of the moment of inertia of the hollow sphere to that of the solid sphere about a diameter is:

(A) 1

(B) $\frac{2}{3}$

(C) $\frac{5}{3}$

(D) $\frac{3}{5}$

Q5. The acceleration due to gravity at the surface of the Earth is g. At a depth $d = R/2$ below the surface (where R is the Earth's radius), the acceleration due to gravity is:

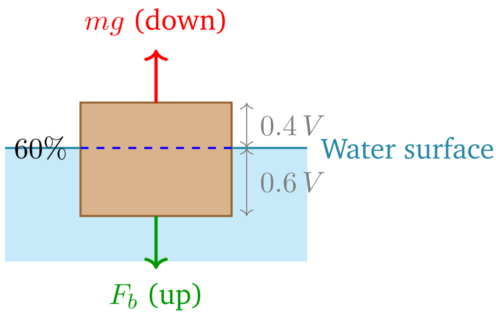
(A) g

(B) $\frac{g}{4}$

(C) $\frac{g}{3}$

(D) $\frac{g}{2}$

Q6. A block of wood has density $\rho_w = 600\ \mathrm{kg/m^3}$ and total volume V. It floats freely in water ($\rho = 1000\ \mathrm{kg/m^3}$). The fraction of the block's volume that is submerged is:



(A) 0.6

(B) 0.4

(C) 0.5

(D) 0.3

Q7. In any spontaneous natural process occurring in an isolated system (for example, heat flowing from a hotter body to a colder body), the total entropy of the system:

(A) Remains constant

(B) Always increases

(C) Always decreases

(D) May increase or decrease depending on the process

Q8. Two particles undergo simple harmonic motion with the same angular frequency ω and the same amplitude A. Particle 1 starts at $x = A$ (maximum displacement, zero velocity) at $t = 0$, while Particle 2 starts at $x = 0$ moving in the positive x-direction at $t = 0$. The phase difference between the two particles is:

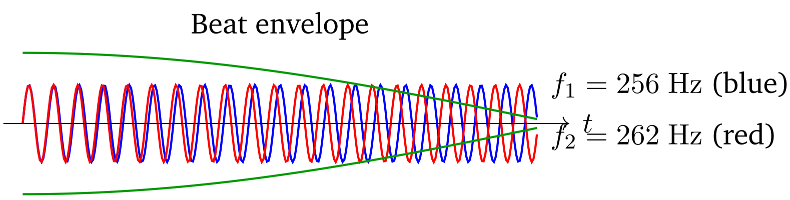
(A) π

(B) $\dfrac{\pi}{4}$

(C) $\dfrac{\pi}{2}$

(D) 2π

Q9. Two tuning forks of frequencies 256 Hz and 262 Hz are sounded simultaneously near each other. The number of beats heard per second is:



(A) 3

(B) 518

(C) 4

(D) 6

Q10. A capacitor of capacitance $C = 4\ \mu\text{F}$ is charged to a potential difference of $V = 50$ V. The energy stored in the capacitor is:

(A) 5 mJ

(B) 10 mJ

(C) 2.5 mJ

(D) 20 mJ

Q11. A resistor of resistance $R = 10\ \Omega$ carries a steady current of $I = 3$ A. The power dissipated as heat in the resistor is:

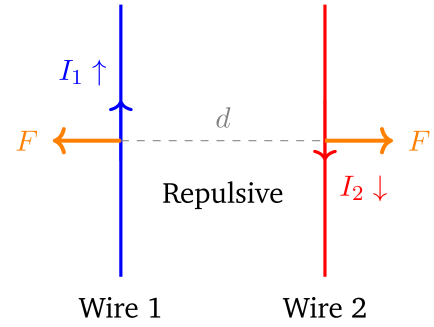
(A) 30 W

(B) 90 W

(C) 45 W

(D) 3 W

Q12. Two long straight parallel wires carry currents in **opposite** directions. The nature of the force between the two wires is:



(A) Attractive

(B) Zero (no force)

(C) Repulsive

(D) Depends on the magnitude of the currents

Q13. A horizontal conducting ring is dropped into a region where the magnetic field B is directed vertically downward and is increasing in magnitude. By Lenz's law, the direction of the induced current in the ring, as viewed from above, is:

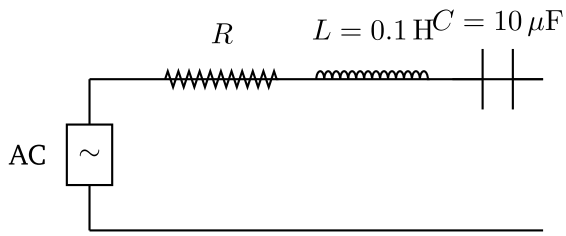
(A) Clockwise, to reinforce the increasing flux

(B) No current is induced since the ring moves along the field

(C) Alternating, switching direction continuously

(D) Counterclockwise, to oppose the increasing downward flux

Q14. A series LCR circuit has inductance $L = 0.1$ H and capacitance $C = 10\ \mu\text{F} = 10^{-5}$ F. The angular frequency at resonance ω_0 (in rad/s) is:



$$\omega_0 = \frac{1}{\sqrt{LC}}$$

(A) 1000 rad/s

(B) 100 rad/s

(C) 500 rad/s

(D) 10000 rad/s

Q15. Visible light travels through vacuum at speed $c = 3 \times 10^8$ m/s. If the frequency of a certain visible light wave is $f = 6 \times 10^{14}$ Hz, its wavelength is:

(A) 300 nm

(B) 500 nm

(C) 700 nm

(D) 200 nm

Q16. A concave (diverging) lens has a focal length of $f = -25$ cm. The power of this lens (in diopters) is:

(A) $+4$ D

(B) $+2.5$ D

(C) -4 D

(D) -2 D

Q17. In a single-slit diffraction experiment, light of wavelength $\lambda = 500$ nm passes through a slit of width $a = 0.1$ mm. The screen is at distance $D = 1$ m. The width of the central maximum on the screen is:

(A) 5 mm

(B) 2 mm

(C) 5 cm

(D) 1 cm

Q18. Using the Rydberg formula, the wavelength of the second line of the Balmer series in hydrogen ($n = 4 \rightarrow n = 2$) is: (Use $R_H = 1.097 \times 10^7 \text{ m}^{-1}$)

(A) 486 nm

(B) 656 nm

(C) 434 nm

(D) 410 nm

Q19. A radioactive sample initially gives a count rate of $N_0 = 1600$ decays per second. After the sample has undergone 3 complete half-lives, the count rate (in decays per second) is:

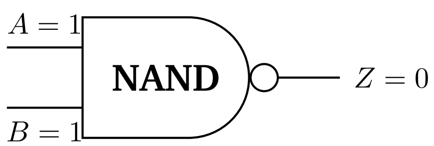
(A) 400

(B) 200

(C) 100

(D) 800

Q20. A NAND gate has two inputs A and B. When both inputs are $A = 1$ and $B = 1$, the output Z is:



(A) 1

(B) Undefined

(C) 0

(D) Depends on the supply voltage

SECTION B (Numerical Value Questions)
Q21 – Q30 Attempt ANY 5 [+4 / 0]

Q21. A ball is thrown vertically upward with initial speed $u = 25$ m/s ($g = 10$ m/s^2). Calculate the maximum height reached by the ball (in metres).

(Enter the exact numerical value as your answer.)

Q22. A ball of mass $m = 0.5$ kg moving at $v = 4$ m/s collides head-on elastically with an identical stationary ball ($m = 0.5$ kg). Calculate the kinetic energy (in joules) transferred to the initially stationary ball.

(Enter the exact numerical value as your answer.)

Q23. A current of $I = 2$ A flows through a resistor of $R = 25\ \Omega$. Calculate the power dissipated (in watts) in the resistor.

(Enter the exact numerical value as your answer.)

Q24. A capacitor of capacitance $C = 8\ \mu$F is charged to a potential difference of $V = 50$ V. Calculate the energy stored in the capacitor (in mJ).

(Enter the exact numerical value as your answer.)

Q25. A series LCR circuit has $L = 1$ H and $C = 0.01$ F. Calculate the angular resonance frequency ω_0 (in rad/s).

(Enter the exact numerical value as your answer.)

Q26. An object is placed at a real depth of 15 cm below the surface of water (refractive index $\mu = 1.5$). Calculate the apparent depth (in cm) of the object when viewed from above.

(Enter the exact numerical value as your answer.)

Q27. Calculate the wavelength (in nm) of a photon whose energy is $E = 3.1$ eV. (Use $hc = 1240$ eV $\cdot$ nm.)

(Enter the exact numerical value as your answer.)

Q28. A radioactive sample initially has a count rate of $N_0 = 3200$ decays per second. After 4 complete half-lives, what is the count rate (in decays per second)?

(Enter the exact numerical value as your answer.)

Q29. A glass prism has apex angle $A = 60^\circ$ and refractive index $\mu = \sqrt{3}$. Calculate the angle of minimum deviation D_m (in degrees).

(Enter the exact numerical value as your answer.)

Q30. Two long parallel wires, separated by a distance $d = 0.1$ m, each carry a current of $I = 5$ A. Calculate the magnetic force per unit length between the wires (in $\mu\mathrm{N/m}$). (Use $\mu_0 = 4\pi \times 10^{-7}\ \mathrm{T \cdot m/A}$.)

(Enter the exact numerical value as your answer.)

DETAILED SOLUTIONS

Sol. Q1.

Solution

Topic: Kinematics — Vertical Throw Upward

The time to reach maximum height (when $v = 0$) is $t_{\text{up}} = u/g = 20/10 = 2$ s.

By symmetry, the time to fall back to the ground equals the time to rise. Therefore:

$$T_{\text{total}} = 2t_{\text{up}} = \frac{2u}{g} = \frac{2 \times 20}{10} = \mathbf{4}\text{ s}$$

Answer: (D)

Sol. Q2.

Solution

Topic: Laws of Motion — Static Friction

The normal force on the block resting on a horizontal surface equals its weight:

$$N = mg = 10 \times 10 = 100\text{ N}$$

The maximum static friction force is:

$$f_{s,\max} = \mu_s N = 0.4 \times 100 = \mathbf{40}\text{ N}$$

Answer: (A)

Sol. Q3.

Solution

Topic: Work-Energy Theorem — Elastic Collision (Equal Masses)

In a perfectly elastic head-on collision between two equal masses where one is initially at rest, the moving ball comes to a complete stop and the stationary ball moves off with the original velocity v.

Kinetic energy of the initially stationary ball after collision:

$$KE_B = \frac{1}{2}mv^2$$

This represents 100% transfer of kinetic energy.

Answer: (B)

Sol. Q4.

Solution

Topic: Rotational Motion — Moment of Inertia Ratio

For a solid sphere about a diameter:

$$I_{\text{solid}} = \frac{2}{5}MR^2$$

For a hollow (thin-shell) sphere about a diameter:

$$I_{\text{hollow}} = \frac{2}{3}MR^2$$

The required ratio:

$$\frac{I_{\text{hollow}}}{I_{\text{solid}}} = \frac{\frac{2}{3}MR^2}{\frac{2}{5}MR^2} = \frac{2}{3} \times \frac{5}{2} = \mathbf{\frac{5}{3}}$$

$\boxed{\textbf{Answer: (C)}}$

Sol. Q5.

Solution

Topic: Gravitation — Variation of g with Depth

The acceleration due to gravity at a depth d below the Earth's surface is:

$$g_d = g\left(1 - \frac{d}{R}\right)$$

At $d = R/2$:

$$g_d = g\left(1 - \frac{R/2}{R}\right) = g\left(1 - \frac{1}{2}\right) = \mathbf{\frac{g}{2}}$$

$\boxed{\textbf{Answer: (D)}}$

Sol. Q6.

Solution

Topic: Fluids — Archimedes' Principle (Floating Body)

For a floating body, the weight of the body equals the buoyant force (weight of displaced water):

$$\rho_w \, V g = \rho_{\text{water}} \, V_{\text{sub}} \, g$$

where V_{sub} is the submerged volume. Solving:

$$\frac{V_{\text{sub}}}{V} = \frac{\rho_w}{\rho_{\text{water}}} = \frac{600}{1000} = \mathbf{0.6}$$

Therefore, 60% of the block is submerged below the water surface.

Answer: (A)

Sol. Q7.

Solution

Topic: Thermodynamics — Second Law / Entropy

The Second Law of Thermodynamics states that for any spontaneous (irreversible) process in an isolated system, the total entropy always increases. Entropy can only remain constant for a perfectly reversible (ideal) process. It can never decrease spontaneously. The entropy statement of the Second Law: $\Delta S_{\text{universe}} \geq 0$, with equality only for reversible processes.

Answer: (B)

Sol. Q8.

Solution

Topic: Oscillations — Phase Difference in SHM

Write the displacement equations:

- Particle 1 starts at $x = A$ (maximum): $x_1 = A\cos(\omega t)$
- Particle 2 starts at $x = 0$ moving in $+x$: $x_2 = A\sin(\omega t) = A\cos(\omega t - \pi/2)$

The phase of Particle 1 is $\phi_1 = 0$ and the phase of Particle 2 is $\phi_2 = -\pi/2$ (or equivalently $3\pi/2$). The phase difference is:

$$\Delta\phi = \phi_1 - \phi_2 = 0 - \left(-\frac{\pi}{2}\right) = \boldsymbol{\frac{\pi}{2}}$$

Answer: (C)

Sol. Q9.

Solution

Topic: Waves — Beats

When two sound waves of slightly different frequencies f_1 and f_2 are superposed, they produce a phenomenon called beats. The number of beats heard per second equals the absolute difference in the two frequencies:

$$f_{\text{beats}} = |f_2 - f_1| = |262 - 256| = \mathbf{6}\ \text{beats/s}$$

Answer: (D)

Sol. Q10.

Solution

Topic: Electrostatics — Energy Stored in a Capacitor

The energy stored in a capacitor is:

$$U = \frac{1}{2}CV^2 = \frac{1}{2} \times 4 \times 10^{-6} \times (50)^2 = \frac{1}{2} \times 4 \times 10^{-6} \times 2500 = 5 \times 10^{-3}\ \text{J} = \mathbf{5}\ \text{mJ}$$

Answer: (A)

Sol. Q11.

Solution

Topic: Current Electricity — Power Dissipation

The power dissipated in a resistor carrying current I is given by Joule's law:

$$P = I^2R = (3)^2 \times 10 = 9 \times 10 = \mathbf{90}\ \text{W}$$

Answer: (B)

Sol. Q12.

Solution

Topic: Magnetism — Force between Parallel Current-Carrying Wires

Two parallel wires carrying currents in the **same** direction attract each other; two wires carrying currents in **opposite** directions repel each other. This can be verified using the right-hand rule for the magnetic field created by each wire and then finding the force on the other wire using $\vec{F} = I(\vec{l} \times \vec{B})$.

Since the currents are in opposite directions, the force between the wires is **repulsive**.

Answer: (C)

Sol. Q13.

Solution

Topic: Electromagnetic Induction — Lenz's Law

The magnetic flux through the ring is directed downward and is increasing. By Lenz's law, the induced current must create a magnetic field that opposes the increase — i.e., the induced magnetic field inside the ring must be directed upward (opposing the increasing downward flux).

Using the right-hand rule: to produce an upward magnetic field through the ring, the current must flow counterclockwise when viewed from above.

Answer: (D)

Sol. Q14.

Solution

Topic: AC Circuits — LCR Resonance Frequency

At resonance, the inductive reactance equals the capacitive reactance: $X_L = X_C$, which gives $\omega_0 L = 1/(\omega_0 C)$. Solving for ω_0:

$$\omega_0 = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{0.1 \times 10^{-5}}} = \frac{1}{\sqrt{10^{-6}}} = \frac{1}{10^{-3}} = \mathbf{1000}\ \mathrm{rad/s}$$

Note: $LC = 0.1\ \mathrm{H} \times 10 \times 10^{-6}\ \mathrm{F} = 10^{-6}\ \mathrm{H \cdot F}$.

Answer: (A)

Sol. Q15.

Solution

Topic: Electromagnetic Waves — Wavelength from Frequency

Using the wave relation $c = f\lambda$:

$$\lambda = \frac{c}{f} = \frac{3 \times 10^8\ \mathrm{m/s}}{6 \times 10^{14}\ \mathrm{Hz}} = 5 \times 10^{-7}\ \mathrm{m} = \mathbf{500}\ \mathrm{nm}$$

This wavelength corresponds to green visible light.

Answer: (B)

Sol. Q16.

Solution

Topic: Ray Optics — Power of a Lens

The power of a lens is defined as the reciprocal of its focal length in metres:

$$P = \frac{1}{f} = \frac{1}{-0.25\ \mathrm{m}} = -\mathbf{4}\ \mathrm{D}$$

The negative sign confirms it is a diverging (concave) lens.

Answer: (C)

Sol. Q17.

Solution

Topic: Wave Optics — Single-Slit Diffraction

The first minima occur at $\sin\theta = \pm\lambda/a$. For small angles, $\theta \approx \lambda/a$. The distance from the centre to the first minimum on the screen is:

$$y_1 = D\tan\theta \approx D\cdot\frac{\lambda}{a} = 1\text{ m}\times\frac{500\times10^{-9}}{0.1\times10^{-3}} = 1\times5\times10^{-3}\text{ m} = 5\text{ mm}$$

The total width of the central maximum (from first minimum on one side to first minimum on the other side) is:

$$W = 2y_1 = 2\times5\text{ mm} = \mathbf{1}\text{ cm}$$

Answer: (D)

Sol. Q18.

Solution

Topic: Atoms — Balmer Series (Second Line, $n = 4 \to n = 2$)

Applying the Rydberg formula:

$$\frac{1}{\lambda} = R_H\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) = R_H\left(\frac{1}{4} - \frac{1}{16}\right) = R_H\times\frac{4-1}{16} = R_H\times\frac{3}{16}$$

$$\lambda = \frac{16}{3R_H} = \frac{16}{3\times1.097\times10^7} = \frac{16}{3.291\times10^7} \approx 4.86\times10^{-7}\text{ m} = \mathbf{486}\text{ nm}$$

This is the blue-green line (Hβ) of the Balmer series.

Answer: (A)

Sol. Q19.

Solution

Topic: Nuclei — Radioactive Decay and Half-Life

After each half-life, the count rate is halved. After n half-lives:

$$N = N_0\times\left(\frac{1}{2}\right)^n = 1600\times\left(\frac{1}{2}\right)^3 = 1600\times\frac{1}{8} = \mathbf{200}\text{ decays/s}$$

Answer: (B)

Sol. Q20.

Solution

Topic: Semiconductors — Logic Gates (NAND)

A NAND gate computes $Z = \overline{A \cdot B}$ (NOT AND). The truth table for inputs $A = 1$, $B = 1$:

$$A \cdot B = 1 \cdot 1 = 1 \implies Z = \overline{1} = \mathbf{0}$$

The NAND gate gives output 0 only when both inputs are 1; for all other input combinations it gives 1.

Answer: (C)

Sol. Q21.

Solution

Topic: Kinematics — Maximum Height of Vertical Throw

At maximum height, the vertical velocity becomes zero. Using $v^2 = u^2 - 2gH$:

$$0 = u^2 - 2gH \implies H = \frac{u^2}{2g} = \frac{(25)^2}{2 \times 10} = \frac{625}{20} = \mathbf{31.25}\ \mathrm{m}$$

Answer: (31.25)

Sol. Q22.

Solution

Topic: Work-Energy — Elastic Collision (Equal Masses)

In an elastic head-on collision between equal masses, the moving ball stops and the stationary ball acquires all the kinetic energy. The kinetic energy transferred to the stationary ball equals the initial kinetic energy of the moving ball:

$$KE = \frac{1}{2}mv^2 = \frac{1}{2} \times 0.5 \times (4)^2 = \frac{1}{2} \times 0.5 \times 16 = \mathbf{4}\ \mathrm{J}$$

Answer: (4)

Sol. Q23.

Solution

Topic: Current Electricity — Power Dissipation

Using Joule's law of heating:

$$P = I^2R = (2)^2 \times 25 = 4 \times 25 = \mathbf{100}\ \mathrm{W}$$

Answer: (100)

Sol. Q24.

Solution

Topic: Electrostatics — Energy Stored in a Capacitor

$$U = \frac{1}{2}CV^2 = \frac{1}{2} \times 8 \times 10^{-6} \times (50)^2 = \frac{1}{2} \times 8 \times 10^{-6} \times 2500 = 10^{-2}\text{ J} = \mathbf{10}\text{ mJ}$$

Answer: (10)

Sol. Q25.

Solution

Topic: AC Circuits — LCR Resonance Angular Frequency

$$\omega_0 = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{1 \times 0.01}} = \frac{1}{\sqrt{10^{-2}}} = \frac{1}{0.1} = \mathbf{10}\text{ rad/s}$$

Answer: (10)

Sol. Q26.

Solution

Topic: Ray Optics — Apparent Depth (Refraction at Flat Surface)

When an object is submerged in a medium of refractive index μ and viewed from above (air), the apparent depth is:

$$d_{\text{apparent}} = \frac{d_{\text{real}}}{\mu} = \frac{15}{1.5} = \mathbf{10}\text{ cm}$$

The object appears to be only 10 cm below the surface.

Answer: (10)

Sol. Q27.

Solution

Topic: Dual Nature — Photon Wavelength from Energy

Using $E = hc/\lambda$, solving for λ:

$$\lambda = \frac{hc}{E} = \frac{1240\text{ eV}\cdot\text{nm}}{3.1\text{ eV}} = \mathbf{400}\text{ nm}$$

This is at the boundary of visible and ultraviolet light (violet end of spectrum).

Answer: (400)

Sol. Q28.

Solution

Topic: Nuclei — Radioactive Decay (Multiple Half-Lives)

After 4 complete half-lives:

$$N = N_0 \times \left(\frac{1}{2}\right)^4 = 3200 \times \frac{1}{16} = \mathbf{200} \text{ decays/s}$$

Answer: (200)

Sol. Q29.

Solution

Topic: Ray Optics — Minimum Deviation in a Prism

At minimum deviation, the prism formula gives:

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

With $A = 60^\circ$ and $\mu = \sqrt{3}$:

$$\sin\left(\frac{60^\circ + D_m}{2}\right) = \sqrt{3} \times \sin 30^\circ = \sqrt{3} \times \frac{1}{2} = \frac{\sqrt{3}}{2}$$

$$\frac{60^\circ + D_m}{2} = 60^\circ \implies 60^\circ + D_m = 120^\circ \implies D_m = \mathbf{60}^\circ$$

Answer: (60)

Sol. Q30.

Solution

Topic: Magnetism — Force per Unit Length between Parallel Wires

The magnetic force per unit length between two parallel wires carrying currents I_1 and I_2 separated by distance d is:

$$\frac{F}{L} = \frac{\mu_0 I_1 I_2}{2\pi d} = \frac{4\pi \times 10^{-7} \times 5 \times 5}{2\pi \times 0.1} = \frac{4\pi \times 10^{-7} \times 25}{2\pi \times 0.1} = \frac{4 \times 25 \times 10^{-7}}{2 \times 0.1} = \frac{100 \times 10^{-7}}{0.2} = 500\times 1$$

Since the currents are in the same direction (not stated otherwise; using force magnitude), the force is attractive at $50\ \mu\mathrm{N/m}$.

Answer: (50)

ANSWER KEY

Section A — MCQ Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	D	2	A	3	B	4	C	5	D
6	A	7	B	8	C	9	D	10	A
11	B	12	C	13	D	14	A	15	B
16	C	17	D	18	A	19	B	20	C

Section B — Numerical Answer Key

Q	Ans	Q	Ans
21	31.25	22	4
23	100	24	10
25	10	26	10
27	400	28	200
29	60	30	50