

JEE MAIN Physics Sample Paper 04

Total Questions: 25 | **Duration:** 1 Hour

Marking Scheme: Correct (+4) | Incorrect MCQ (-1) | Incorrect NVT (0)

Section A: Multiple Choice Questions (1-20)

1. Dimensional formula for Young's modulus using speed (V), acceleration (A), and force (F) as base:

A. (A) $V^{-4}A^2F^1$

B. (B) $V^{-2}A^2F^2$

C. (C) $V^4A^{-2}F$

D. (D) $V^{-2}A^2F^{-2}$

2. A stone thrown at 30° to horizontal. Ratio of KE at projection to KE at highest point:

A. (A) 4:3

B. (B) 4:1

C. (C) 1:2

D. (D) 1:4

3. Extension to natural length ratio for a 200g mass on 12.5 N/m spring moving at 5 rad/s:

A. (A) 1:2

B. (B) 2:3

C. (C) 1:1

D. (D) 2:5

4. Power factor of LCR circuit with $V_R = 10V$, $V_L = 20V$, $V_C = 20V$:

A. (A) 0.5

B. (B) 1.0

C. (C) 0.707

D. (D) 0.8

5. Emergent intensity of unpolarised light I_0 through two polaroids at 45° :

A. (A) $I_0/2$

B. (B) $I_0/8$

C. (C) $I_0/4$

D. (D) I_0

6. Modulation index for carrier $2 \sin(8\pi t)$ and square wave signal of amplitude 1:

A. (A) 0.5

B. (B) 1.0

C. (C) 0.25

D. (D) 0.33

7. Magnetic field inside 70 turns/cm solenoid carrying 2.0 A:

A. (A) $1.76 \times 10^{-2} \text{ T}$

B. (B) $8.8 \times 10^{-3} \text{ T}$

C. (C) $1.23 \times 10^{-1} \text{ T}$

D. (D) $3.52 \times 10^{-2} \text{ T}$

8. Max line of sight distance for two 80m antennas:

A. (A) 32 km

B. (B) 64 km

C. (C) 36 km

D. (D) 28 km

9. Safe speed for car on 50m curve with $\mu = 0.34$:

A. (A) 13 m/s

B. (B) 17 m/s

C. (C) 22.4 m/s

D. (D) 10 m/s

10. Induced EMF in circular loop ($r = 10/\sqrt{\pi} \text{ cm}$) in 0.5T field dropping to zero in 0.5s:

A. (A) 10 mV

B. (B) 1 mV

C. (C) 5 mV

D. (D) 100 mV

11. Ratio of density of Oxygen nucleus to Helium nucleus:

- | | |
|------------|------------|
| A. (A) 1:1 | B. (B) 4:1 |
| C. (C) 2:1 | D. (D) 8:1 |
-

12. Stopping potential shift when λ changes from 300nm to 400nm:

- | | |
|--------------|--------------|
| A. (A) 1.0 V | B. (B) 2.0 V |
| C. (C) 0.5 V | D. (D) 1.5 V |
-

13. Carnot engine efficiency inc from 50% to 70% (Source 600K). New source temp:

- | | |
|---------------|--------------|
| A. (A) 1000 K | B. (B) 900 K |
| C. (C) 800 K | D. (D) 750 K |
-

14. Resistance of wire recast into half radius:

- | | |
|----------------------|---------------------|
| A. (A) 1600 Ω | B. (B) 400 Ω |
| C. (C) 800 Ω | D. (D) 100 Ω |
-

15. Position of food packet from helicopter (v, h) when manually dropped:

- | | |
|---------------------------------|---------------------------|
| A. (A) $\sqrt{[2v^2h/g + h^2]}$ | B. (B) $\sqrt{[2v^2h/g]}$ |
| C. (C) v^2/g | D. (D) h |
-

16. Mass number and atomic number of A_6 in decay $A(218, 84) \rightarrow \dots \rightarrow A_6$:

- | | |
|----------------|----------------|
| A. (A) 210, 84 | B. (B) 210, 80 |
| C. (C) 210, 82 | D. (D) 211, 80 |
-

17. Work in conversion of 1g liquid to vapor at 3×10^5 Pa ($\Delta V = 1600 \text{ cm}^3$):

- | | |
|--------------|---------------|
| A. (A) 480 J | B. (B) 4800 J |
| C. (C) 432 J | D. (D) 4320 J |
-

18. Brewster's angle relation air $\rightarrow$ glass is θ_B . glass $\rightarrow$ air is:

- | | |
|---------------------------|--------------------|
| A. (A) $\pi/2 - \theta_B$ | B. (B) θ_B |
| C. (C) $\pi - \theta_B$ | D. (D) $2\theta_B$ |

19. Magnetic induction at center of equilateral triangle side 4.5×10^{-2} m carrying 1A:

- | | |
|-----------------------------|-----------------------------|
| A. (A) 4×10^{-5} T | B. (B) 8×10^{-5} T |
| C. (C) 2×10^{-5} T | D. (D) Zero |

20. Net work in cycle (Isothermal expansion 2V, Isobaric compression V_1 , Isochoric return):

- | | |
|---------------------------|--------------------|
| A. (A) $nRT(\ln 2 - 0.5)$ | B. (B) $nRT \ln 2$ |
| C. (C) $nRT(\ln 2 + 0.5)$ | D. (D) Zero |

Section B: Numerical Value Questions (21-25)

21. Stretch copper wire length 20% increase. % Resistance increase: _____

22. Ball dropped from 20m, $e = 0.5$. Rebound height (m): _____

23. Mass m (kg) on spring for 1s to 2s period change after adding 3kg: _____

24. Energy lost (nJ) in 60pF capacitor charge sharing: _____

25. Max range 100m. Max vertical throw height (m): _____

Answer Key & Detailed Explanation

1. [A] Young's Modulus $[ML^{-1}T^{-2}]$. Dimensional analysis using V, A, F yields $V^{-4}A^2F^1$.

2. [A] $KE_{proj} = \frac{1}{2}mu^2$; $KE_{top} = \frac{1}{2}m(u \cos 30^\circ)^2$. Ratio = $1 / \cos^2 30^\circ = 1 / (3/4) = 4:3$.

3. [C] Balancing $kx = mr\omega^2$ with given mass and angular velocity, the ratio is 1:1.

4. [B] At resonance ($V_L = V_C$), $Z = R$. Power factor $\cos\phi = R/Z = 1.0$.

5. [C] Intensity after 1st polaroid = $I_0/2$. After 2nd at 45° , $I = (I_0/2)\cos^2 45^\circ = I_0/4$.

6. [A] Modulation Index $m = A_m / A_c$. For square wave amplitude 1 and carrier 2, $m = 1/2 = 0.5$.

7. [A] $B = \mu_0 ni$. $n = 70 \text{ turns/cm} = 7000 \text{ turns/m}$. $B = (4\pi \times 10^{-7}) \times 7000 \times 2.0 \approx 1.76 \times 10^{-2} \text{ T}$.

8. [B] LOS distance = $\sqrt{(2Rh_1)} + \sqrt{(2Rh_2)}$. For $h=80\text{m}$, $d = 2 \times \sqrt{(2 \times 6400 \times 0.08)} \approx 64 \text{ km}$.

9. [A] $V = \sqrt{\mu rg} = \sqrt{(0.34 \times 50 \times 10)} = \sqrt{170} \approx 13 \text{ m/s}$.

10. [B] Induced EMF = $|\Delta\Phi/\Delta t| = (\pi r^2 \times \Delta B) / \Delta t$. For $r=10/\sqrt{\pi} \text{ cm}$, $\epsilon = 1 \text{ mV}$.

11. [A] Nuclear density is independent of mass number A . Ratio is always 1:1.

12. [C] $\Delta V = (hc/e)(1/\lambda_1 - 1/\lambda_2)$. Calculation yields approx 0.5 V shift.

13. [A] Efficiency $\eta = 1 - T_{\text{sink}}/T_{\text{source}}$. Solving for new source temp gives 1000 K.

14. [A] Radius becomes $r/2$, Area becomes $A/4$, Length becomes $4L$. New $R = 16R = 1600 \Omega$.

15. [B] Position relative to drop point $= \sqrt{(vt)^2 + h^2}$. Time $t = \sqrt{2h/g}$. Result is $\sqrt{[2v^2h/g + h^2]}$.

16. [C] In α -decay, mass drops by 4 and atomic number by 2. Sequence leads to (210, 82).

17. [A] Work $W = P\Delta V = (3 \times 10^5) \times (1600 \times 10^{-6}) = 480 \text{ J}$.

18. [A] Statement derived from Brewster's Law and principle of reversibility. Both are true.

19. [B] B at center $= 3 \times (\mu_0 I / 4\pi r)(\sin 60^\circ + \sin 60^\circ)$. Result is $8 \times 10^{-5} \text{ T}$.

20. [A] Total work $= nRT \ln 2 - P\Delta V$. Simplifies to $nRT(\ln 2 - 0.5)$.

21. [44] Stretch factor 1.2: $R' = (1.2)^2 R = 1.44R$. Increase = 44%.

22. [5] Rebound height $h' = e^2 h = (0.5)^2 \times 20 = 5 \text{ m}$.

23. [1] $T^2 \propto m$. $(2/1)^2 = (m+3)/m \rightarrow 4m = m+3 \rightarrow m = 1 \text{ kg}$.

24. [120] Energy loss in redistribution based on 60pF sharing = 120 nJ.

25. [50] Max range $R = 100$. Vertical height $H = u^2/2g = R/2 = 50 \text{ m}$.