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Experimental Skills — JEE (Main) Pattern Topic Test

FREE SAMPLE TEST · PHYSICS · PATTERN OF JEE (MAIN)

DURATION	MAXIMUM MARKS	QUESTIONS	NAME / ROLL NO.
60 minutes	100	25 (20 + 5)	

GENERAL INSTRUCTIONS

1. This question paper has two sections, A and B. All 25 questions are compulsory.
2. Section A has TWENTY (20) multiple-choice questions. Each has FOUR options, (1), (2), (3) and (4), of which ONLY ONE is correct.
3. Section B has FIVE (05) questions whose answer is a numerical value. Enter the value rounded off to the nearest integer.
4. Marking scheme for both sections: +4 for a correct answer, −1 for an incorrect answer, 0 if the question is not attempted.
5. Take g = 10 m/s² unless stated otherwise. Use of a calculator, log tables or any other aid is not allowed.
6. The answer key and worked solutions are at the end of this booklet. Attempt the paper in 60 minutes before you look at them.

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Topics covered: Vernier callipers and screw gauge · Simple pendulum: dissipation of energy · Metre scale: mass by the principle of moments · Young's modulus of a wire · Surface tension by capillary rise · Viscosity by terminal velocity · Speed of sound by resonance tube · Specific heat by the method of mixtures · Resistivity using a metre bridge · Resistance using Ohm's law · Galvanometer: half-deflection method · Focal length by the parallax method · Prism: angle of deviation against angle of incidence · Refractive index of a glass slab by travelling microscope · Characteristic curves of p–n junction and Zener diodes · Identification of electronic components

SECTION A (Q1–20) · Multiple choice · +4 / 0 / −1

Each question has FOUR options. ONLY ONE of them is correct.

1. In a vernier calliper, 10 vernier divisions equal 9 main-scale divisions of 1 mm. With the jaws closed, the vernier zero is to the right of the main-scale zero and the 3rd vernier division coincides with a main-scale division. Measuring the depth of a vessel, the main-scale reading is 3.1 cm and the 6th vernier division coincides. The corrected depth is

(1) 3.13 cm

(2) 3.19 cm

(3) 3.16 cm

(4) 3.10 cm

2. A screw gauge has a pitch of 0.5 mm and 50 divisions on its circular scale. With the jaws closed it reads −0.04 mm. Measuring a wire, the main-scale reading is 2.5 mm and the 36th circular division is on the reference line. The diameter of the wire is

(1) 2.82 mm

(2) 2.86 mm

(3) 3.26 mm

(4) 2.90 mm

3. In the experiment to study the dissipation of energy of a simple pendulum, its amplitude is found to fall from 10 cm to 5 cm in 60 s, the decay being exponential. The time in which its energy falls to half is

(1) 60 s

(2) 120 s

(3) 30 s

(4) 15 s

4. A uniform metre scale is balanced on a knife edge at its 50 cm mark. An unknown mass is hung at the 10 cm mark and a 50 g mass at the 80 cm mark, and the scale stays balanced at the 50 cm mark. The unknown mass is

(1) 50 g

(2) 37.5 g

(3) 66.7 g

(4) 40 g

5. In Searle's experiment, a load of 4 kg stretches a wire 2 m long and 0.5 mm in diameter by 2 mm. The Young's modulus of the wire is about ($g = 10\ m/s^2$)

(1) $1.0 \times 10^{11}\ N/m^2$

(2) $2.0 \times 10^{11}\ N/m^2$

(3) $4.1 \times 10^{11}\ N/m^2$

(4) $5.1 \times 10^{10}\ N/m^2$

6. Water rises 3 cm in a clean glass capillary tube of radius 0.5 mm (angle of contact zero; density 1000 kg/m³; g = 10 m/s²). The surface tension of water, and the effect of adding a little detergent to the water, are

(1) 0.15 N/m, and the rise increases

(2) 0.075 N/m, and the rise increases

(3) 0.075 N/m, and the rise decreases

(4) 0.0375 N/m, and the rise decreases

7. A steel ball of radius 1 mm (density 7800 kg/m³) falls through glycerine (density 1260 kg/m³) with a terminal speed of 2 cm/s. The coefficient of viscosity of glycerine is about (g = 10 m/s²)

(1) 0.36 Pa s

(2) 1.45 Pa s

(3) 7.3 Pa s

(4) 0.73 Pa s

8. In a resonance tube experiment with a 500 Hz tuning fork, the first and second resonances occur at air-column lengths of 16 cm and 50 cm. The speed of sound and the end correction are

(1) 340 m/s and 1 cm

(2) 340 m/s and 2 cm

(3) 330 m/s and 1 cm

(4) 680 m/s and 1 cm

9. A 100 g metal block at 100 °C is dropped into 200 g of water at 20 °C in a calorimeter of water equivalent 10 g. The final temperature is 25 °C. The specific heat capacity of the metal is about (specific heat of water 4200 J/kg K; no heat lost)

(1) 588 J/kg K

(2) 560 J/kg K

(3) 294 J/kg K

(4) 1176 J/kg K

10. A 50 cm length of wire of diameter 0.4 mm is placed in the left gap of a metre bridge and a 3 Ω resistor in the right gap. The balance point is 40 cm from the left end. The resistivity of the material of the wire is about

(1) 1.0×10^{-6} Ω m

(2) 2.5×10^{-7} Ω m

(3) 5.0×10^{-7} Ω m

(4) 1.3×10^{-7} Ω m

11. In an Ohm's law experiment the readings (current, voltage) are (0.2 A, 1.1 V), (0.4 A, 2.1 V), (0.6 A, 3.0 V) and (0.8 A, 4.1 V). The resistance found from the best straight line through these points is

(1) about 2.5 Ω

(2) about 5 Ω

(3) about 10 Ω

(4) about 0.2 Ω

12. In the half-deflection method, a galvanometer in series with a resistance of 1000 Ω and a cell gives a certain deflection. A shunt of 50 Ω connected across the galvanometer halves the deflection, the 1000 Ω being unchanged. The resistance of the galvanometer is about

(1) 50 Ω

(2) 1000 Ω

(3) 100 Ω

(4) 52.6 Ω

13. A galvanometer of resistance 50 Ω is connected in series with a 4950 Ω resistor across a 2 V cell of negligible internal resistance and shows a deflection of 30 divisions. Its figure of merit (current per division) is about

(1) 6.7×10^{-2} A/div

(2) 4.0×10^{-4} A/div

(3) 1.3×10^{-6} A/div

(4) 1.3×10^{-5} A/div

14. In finding the focal length of a concave mirror by the parallax method, the image of an object needle placed 24 cm from the mirror shows no parallax with a second needle placed 40 cm from the mirror. The focal length of the mirror is

(1) 16 cm

(2) 15 cm

(3) 32 cm

(4) 64 cm

15. In the i–δ experiment with a prism of angle 60°, the graph of deviation against angle of incidence shows a minimum deviation of 38° at an angle of incidence of 49°. The refractive index of the prism is about

(1) 1.33

(2) 1.71

(3) 1.51

(4) 1.62

16. A travelling microscope is focused on a mark on paper (reading 2.100 cm), then on the mark seen through a glass slab placed on it (reading 2.500 cm), and then on fine powder sprinkled on top of the slab (reading 3.300 cm). The refractive index of the glass is

(1) 1.5

(2) 1.33

(3) 1.6

(4) 2.0

17. The forward characteristic of a diode shows almost no current until about 0.3 V, after which the current rises steeply. The diode is most likely made of

(1) silicon

(2) gallium arsenide

(3) germanium

(4) carbon

18. Readings of reverse voltage (V) and reverse current (mA) for a Zener diode are (2.0, 0), (4.0, 0), (5.0, 0.01), (5.5, 0.1), (5.6, 5), (5.6, 15), (5.6, 30). The reverse breakdown voltage of the diode is

(1) 5.6 V

(2) 5.0 V

(3) 2.0 V

(4) 30 V

19. In a mixed collection of components, one item, when connected to a dc source through a multimeter, shows a large current at first which then falls to zero. The item is

(1) a resistor

(2) a diode

(3) an LED

(4) a capacitor

20. In a Young's modulus experiment the diameter of the wire, 0.50 mm, is measured with a screw gauge of least count 0.01 mm, and the extension, 0.80 mm, with a micrometer of least count 0.01 mm. The load and length are known exactly. The maximum percentage error in Y is

(1) 3.25%

(2) 5.25%

(3) 4.0%

(4) 2.0%

SECTION B (Q21–25) · Numerical value · +4 / 0 / −1

The answer to each question is a NUMERICAL VALUE. Enter it rounded off to the nearest integer.

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21. In a vernier calliper, 20 vernier divisions equal 19 main-scale divisions of 1 mm each. Its least count (in μm) is _____.

Answer: _____

22. With a 512 Hz tuning fork, the first resonance in a resonance tube occurs at an air-column length of 16.0 cm. The end correction is 0.6 cm. The speed of sound (in m/s) is _____ (to the nearest integer).

Answer: _____

23. A uniform metre scale balances on a knife edge at its 40 cm mark when a 20 g mass hangs at its 10 cm mark. The mass of the metre scale (in g) is _____.

Answer: _____

24. A 150 g piece of copper (specific heat 400 J/kg K) at 100 °C is dropped into 100 g of water (specific heat 4200 J/kg K) at 20 °C. Neglecting the calorimeter and heat losses, the final temperature (in °C) is _____.

Answer: _____

25. Water (surface tension 0.07 N/m, density 1000 kg/m³, angle of contact zero) is drawn up a glass capillary of radius 0.2 mm. The height (in mm) to which it rises is _____ ($g = 10$ m/s²).

Answer: _____

END OF THE QUESTION PAPER

ANSWER KEY

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
(1)	(4)	(3)	(2)	(2)	(3)	(4)	(1)	(1)	(3)

Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20
(2)	(4)	(4)	(2)	(3)	(1)	(3)	(1)	(4)	(2)

Q21	Q22	Q23	Q24	Q25
50	340	60	30	70

WORKED SOLUTIONS

Q1. Answer (1). Least count = 1 MSD − 1 VSD = 1 − 0.9 = 0.1 mm. Zero error = +3 × 0.1 = +0.3 mm (vernier zero to the right). Observed reading 31 + 6 × 0.1 = 31.6 mm. Corrected = 31.6 − 0.3 = 31.3 mm = 3.13 cm.

Q2. Answer (4). Least count = 0.5/50 = 0.01 mm. Observed reading 2.5 + 36 × 0.01 = 2.86 mm. Corrected reading = observed − zero error = 2.86 − (−0.04) = 2.90 mm.

Q3. Answer (3). $A = A_0 e^{(-t/\tau)}$ and $E \propto A^2$, so $E = E_0 e^{(-2t/\tau)}$: the energy decays twice as fast. The amplitude halves in 60 s, so the energy halves in 30 s (it falls to a quarter in 60 s). A graph of $\ln A^2$ against t is a straight line.

Q4. Answer (2). The weight of the scale acts at the knife edge and gives no moment. Taking moments about the 50 cm mark: m × 40 = 50 × 30, so m = 37.5 g.

Q5. Answer (2). $Y = FL/(A\Delta L)$ with $A = \pi(0.25 \times 10^{-3})^2 = 1.96 \times 10^{-7}$ m². $Y = 40 \times 2/(1.96 \times 10^{-7} \times 2 \times 10^{-3}) \approx 2.0 \times 10^{11}$ N/m² (a steel wire).

Q6. Answer (3). $h = 2T\cos\theta/(r\rho g)$, so $T = rh\rho g/2 = 0.5 \times 10^{-3} \times 0.03 \times 1000 \times 10/2 = 0.075$ N/m. Detergent lowers the surface tension, so the water rises less.

Q7. Answer (4). At terminal speed, weight − buoyancy = Stokes drag: $(4/3)\pi r^3(\rho - \sigma)g = 6\pi\eta rv$. So $\eta = 2r^2(\rho - \sigma)g/(9v) = 2 \times 10^{-6} \times 6540 \times 10/(9 \times 0.02) \approx 0.73$ Pa s.

Q8. Answer (1). $l_1 + e = \lambda/4$ and $l_2 + e = 3\lambda/4$, so $l_2 - l_1 = \lambda/2 = 34$ cm: λ = 68 cm and v = 500 × 0.68 = 340 m/s. $e = \lambda/4 - l_1 = 17 - 16 = 1$ cm.

Q9. Answer (1). Heat lost by the metal = heat gained by water and calorimeter: 0.1 × c × 75 = 0.21 × 4200 × 5. c = 4410/7.5 = 588 J/kg K. (Ignoring the calorimeter gives 560 J/kg K.)

Q10. Answer (3). X/3 = 40/60, so X = 2 Ω. $\rho = XA/L = 2 \times \pi(0.2 \times 10^{-3})^2/0.5 = 2 \times 1.257 \times 10^{-7}/0.5 \approx 5.0 \times 10^{-7}$ Ω m.

Q11. Answer (2). R is the slope of the V–I graph. The best-fit line has slope $\Delta V/\Delta I \approx (4.1 - 1.1)/(0.8 - 0.2) = 3.0/0.6 = 5$ Ω (least squares gives 4.95 Ω). 0.2 Ω is the slope of the I–V graph instead.

Q12. Answer (4). Without the shunt $I_g = E/(R + G)$. With the shunt, half of this must flow through G: $G = RS/(R - S) = 1000 \times 50/950 \approx 52.6$ Ω. (G ≈ S is only the limit R ≫ S.)

Q13. Answer (4). $I = 2/(4950 + 50) = 4 \times 10^{-4}$ A. Figure of merit $k = I/\theta = 4 \times 10^{-4}/30 \approx 1.3 \times 10^{-5}$ A per division. (4.0×10^{-4} A is the current itself.)

Q14. Answer (2). Both needles are in front of the mirror: u = −24 cm, v = −40 cm. $1/f = 1/v + 1/u = -1/40 - 1/24 = -1/15$, so the focal length is 15 cm.

Q15. Answer (3). At minimum deviation r = A/2 = 30° and i = (A + δ)/2 = 49°, consistent with the graph. n = sin 49°/sin 30° = 0.755/0.5 ≈ 1.51.

Q16. Answer (1). Real thickness = 3.300 − 2.100 = 1.200 cm. Apparent thickness = 3.300 − 2.500 = 0.800 cm. n = real/apparent = 1.5.

Q17. Answer (3). The knee (cut-in) voltage is about 0.2–0.3 V for germanium, about 0.7 V for silicon and higher for wider-gap materials such as gallium arsenide (used in LEDs).

Q18. Answer (1). Breakdown is where the current rises steeply while the voltage stays almost constant: from 5 mA to 30 mA the voltage stays at 5.6 V. That constant voltage is what makes the diode useful as a regulator.

Q19. Answer (4). A capacitor charges up: the current is large at first and dies away as its voltage approaches the source voltage, then no steady current flows. A resistor gives a steady current; a diode or LED conducts steadily in one direction only (an LED also glows).

Q20. Answer (2). $Y = 4FL/(\pi d^2 \Delta L)$, so $\Delta Y/Y = 2(\Delta d/d) + \Delta(\Delta L)/\Delta L = 2 \times (0.01/0.50) + 0.01/0.80 = 4\% + 1.25\% = 5.25\%$.

Q21. Answer 50. 1 VSD = 19/20 mm = 0.95 mm. Least count = 1 MSD − 1 VSD = 0.05 mm = 50 μm.

Q22. Answer 340. $l_1 + e = \lambda/4$: $\lambda = 4 \times 16.6 = 66.4$ cm. $v = 512 \times 0.664 \approx 340$ m/s.

Q23. Answer 60. The scale's weight acts at its 50 cm mark, 10 cm from the knife edge; the 20 g mass is 30 cm on the other side. M × 10 = 20 × 30, so M = 60 g.

Q24. Answer 30. 0.15 × 400 × (100 − T) = 0.1 × 4200 × (T − 20): 60(100 − T) = 420(T − 20), so 6000 + 8400 = 480T and T = 30 °C.

Q25. Answer 70. $h = 2T/(r\rho g) = 2 \times 0.07/(0.2 \times 10^{-3} \times 1000 \times 10) = 0.07$ m = 70 mm.

All questions are original and © Master Testing Agency. Free to download and use for personal practice; not for resale. Every answer in this paper was checked independently by computer: scale readings by simulating the instruments, the pendulum and the falling ball by step-by-step integration, circuits by solving them, and graphs by least squares.