Grade 12 Physics Model Paper 3

MODEL PAPER

Full marks 75 · 3 hours

Name _____ Class _____ Roll no. _____ Date _____ Marks _____ / 75

Answer every question; where a question has an OR question, answer either one. Time: 3 hours.

A practice paper by Science Playground, made to CDC's Specification Grid 2078, Grade 12 Physics (Phy. 102); not an official CDC or NEB paper. Mark it yourself online: the QR code below opens the paper with its answers.

A full practice run of the NEB Grade 12 Physics paper (Phy. 102): 75 marks in 3 hours, 12 questions in three groups. Group A is one question of 11 multiple-choice items, about 25 minutes; groups B and C have short- and long-answer questions of two to four parts, with each part's marks shown. Questions 3 and 9 in group B and Questions 10 and 11 in group C each have an OR question: answer either the question or its OR question, every part from the same one, and mark only the one you answered. Write on paper first, then tap your choice in group A and open each other part's answer to give yourself the marks its scheme allows. Where needed, take $g = 9.8$ m/s², $h = 6.62 \times 10^{-34}$ J s, $c = 3 \times 10^{8}$ m/s, $e = 1.6 \times 10^{-19}$ C, the mass of an electron $m_e = 9.1 \times 10^{-31}$ kg and $\mu_0 = 4\pi \times 10^{-7}$ T m/A.

Group A Multiple choice — 11 marks

Question 1 — 11 × 1 = 11

Choose the correct option for each of the following questions.

a. Which of these is true of the acceleration of a body in simple harmonic motion?

(i) It is constant in size and direction.
(ii) It is greatest at the mean position.
(iii) It is proportional to the displacement and always directed towards the mean position.
(iv) It is proportional to the velocity and in the same direction.

b. Honey poured from a jar on a cold winter morning flows much more slowly than on a warm afternoon. Why?

(i) Honey becomes denser when warm.
(ii) The viscosity of a liquid decreases as its temperature rises.
(iii) The viscosity of a liquid increases as its temperature rises.
(iv) Surface tension holds cold honey in the jar.

c. What is the moment of inertia of a uniform disc of mass 2.0 kg and radius 0.10 m about the axis through its center, at right angles to its face?

(i) 0.0050 kg m² (ii) 0.010 kg m² (iii) 0.020 kg m² (iv) 0.10 kg m²

d. A gas is heated in a closed steel cylinder whose volume cannot change. Where does all the heat given to it go?

(i) into work done by the gas on the cylinder
(ii) into the internal energy of the gas, raising its temperature
(iii) half into work and half into internal energy
(iv) out through the walls as fast as it comes in

e. 1,000 J of heat is given slowly to a large tank of water kept at 27 °C. What is the change in the water's entropy?

(i) 37 J/K (ii) 3.3 J/K (iii) 0.30 J/K (iv) 27,000 J/K

f. Newton's corpuscular theory and Huygens' wave theory both explained refraction. Which prediction decided between them?

(i) whether light travels in straight lines
(ii) whether light reflects at equal angles
(iii) whether light travels faster or slower in water than in air
(iv) whether light carries energy

g. Lhakpa looks at the blue sky through a polaroid and turns it slowly. The sky gets brighter and darker, but never goes dark. What does this show about the light from the sky?

(i) It is unpolarized. (ii) It is partially polarized.
(iii) It is completely plane-polarized. (iv) It is not a transverse wave.

h. A current passes through a copper–iron couple, heating one junction and cooling the other. What happens when the current is reversed?

(i) Both junctions are heated.
(ii) Both junctions are cooled.
(iii) The junction that was heated is now cooled, and the other heated.
(iv) Nothing changes.

i. An iron nail held by a magnet is heated red-hot, past 770 °C. It falls off. Why?

(i) Iron melts at that temperature.
(ii) Heating makes the nail diamagnetic.
(iii) Above its Curie temperature, iron loses its ferromagnetism and becomes paramagnetic.
(iv) Heating makes the magnet's poles change places.

j. The current in a coil of self-inductance 0.20 H falls steadily from 4.0 A to zero in 0.10 s. What e.m.f. is induced in the coil?

(i) 0.08 V (ii) 2.0 V (iii) 8.0 V (iv) 80 V

k. What is the SI unit of the activity of a radioactive sample?

(i) the curie (ii) the becquerel (iii) the sievert (iv) the rutherford

Group B Short answers, each on one content area — 40 marks

Question 2 — 5 marks

Water flows smoothly along a horizontal pipe that narrows from a wide section to a narrow one.

a. State Bernoulli's principle. **[1]**

b. Explain why the pressure is lower in the narrow section of the pipe. **[2]**

c. Two boats moving fast side by side, close together on a river, are found to be pulled towards each other. Roshan says it is because the water between them is pushed out and the boats move into the gap. Is he right? Explain. **[2]**

Question 3 — 5 marks

A solid disc and a solid sphere, each of mass 2.0 kg and radius 0.20 m, roll without slipping along a level floor at 3.0 m/s.

a. Define the radius of gyration of a body. **[1]**

b. Calculate the total kinetic energy of the rolling disc. **[2]**

c. Sagar says the sphere and the disc have the same kinetic energy, because they have the same mass and speed. Is he right? Justify your answer. **[2]**

OR

A small mass hung on a light spring stretches it by 4.9 cm. The mass is then pulled down a little and let go.

a. What is meant by damped oscillation? **[1]**

b. Calculate the period of its oscillation. **[2]**

c. Sneha says that on the Moon, where g is a sixth of the Earth's, the same mass and spring would oscillate with a longer period. Is she right? Justify your answer. **[2]**

Question 4 — 5 marks

Air in a cylinder at 27 °C is compressed suddenly to half its volume. Take γ = 1.4 for air.

a. What is an adiabatic process? **[1]**

b. Explain why, on a P–V diagram, an adiabatic curve is steeper than an isothermal curve through the same point. **[2]**

c. Calculate the temperature of the air after the compression. **[1]**

d. The same air, starting from the same state, can expand to twice its volume either isothermally or adiabatically. In which case does it do more work? Give a reason. **[1]**

Question 5 — 5 marks

In a Young's double-slit experiment, the slits are 0.50 mm apart and the screen is 1.0 m from them. Light of wavelength 600 nm is used.

a. What are coherent sources? **[1]**

b. Calculate the fringe width, and the distance of the third bright fringe from the central bright fringe. **[2]**

c. Shreya covers one slit with black paper. She expects the same fringes, only half as bright. Is she right? Explain. **[2]**

Question 6 — 5 marks

Prakriti wants to make a magnetic field meter from a thin strip of copper 0.10 mm thick, carrying a current of 5.0 A at right angles to a magnetic field of 1.0 T. Copper has 8.5×10^{28} free electrons per m³.

a. What is the Hall effect? **[1]**

b. Calculate the Hall voltage across her copper strip, and judge whether her plan is sensible. Suggest a better choice of material, with a reason. **[3]**

c. If the copper strip were replaced by a strip of p-type semiconductor, carrying the same current in the same field, would the Hall voltage have the same sign? Give a reason. **[1]**

Question 7 — 5 marks

Bishal compares the e.m.f.s of two cells with a potentiometer.

a. State Kirchhoff's two laws. **[2]**

b. Why does a potentiometer measure the e.m.f. of a cell more accurately than a voltmeter does? **[1]**

c. Bishal slides the jockey along the whole wire, but the galvanometer deflects the same way everywhere and he finds no balance point. Suggest two possible reasons. **[2]**

Question 8 — 5 marks

In a Thomson-type tube, electrons from a hot cathode are accelerated through 2,000 V and then pass between plates where an electric field and a magnetic field of 1.0 mT act at right angles to each other and to the beam. The beam goes straight through when the electric field is 2.65×10^4 V/m.

a. Calculate the speed of the electrons and their specific charge, e/m. **[3]**

b. Thomson's experiment gave e/m for the electron, but not e or m separately. Explain how the mass of the electron was then found, and what so large a value of e/m told scientists. **[2]**

Question 9 — 5 marks

LIGO's two detectors, at Hanford and Livingston in the USA, are about 3,000 km apart. Each has two arms 4 km long at right angles.

a. Write any three properties of gravitational waves. **[3]**

b. What is the greatest time between a gravitational wave reaching the two detectors? A wave changes the length of each arm by one part in 10^{21}: by how much does each arm change? **[2]**

OR

A Zener diode of breakdown voltage 5.0 V is joined in series with a 350 Ω resistor across a 12 V supply, to keep a 5.0 V output across a 500 Ω load connected across the Zener.

a. Write any three differences between an ordinary junction diode and a Zener diode. **[3]**

b. Calculate the current through the 350 Ω resistor and the current through the Zener diode. **[2]**

Group C Long answers, each on one content area — 24 marks

Question 10 — 8 marks

Light of wavelength 500 nm falls on a single slit 0.20 mm wide, and the diffraction pattern is seen on a screen 2.0 m away.

a. Calculate the angle of the first minimum and the width of the central bright band on the screen. **[2]**

b. The pupil of Rakshya's eye is 3.0 mm across. For light of 550 nm, find the smallest angle her eye can resolve, and the farthest distance at which she can see a car's two headlights, 1.4 m apart, as two separate lights. **[2]**

c. Rakshya then narrows the slit, expecting the central band to get narrower. Is she right? Explain. **[2]**

d. Explain why astronomers build telescopes with mirrors many meters across, and why a radio telescope, which receives radio waves about 21 cm long, must be far larger still. **[2]**

OR

Newton worked out the speed of sound in air from $v = \sqrt{P/\rho}$. Take the pressure of the air as 1.01×10^5 Pa, its density at 0 °C as 1.29 kg/m³, and $\gamma = 1.4$.

a. Calculate the speed of sound at 0 °C by Newton's formula and by Laplace's corrected formula. **[2]**

b. Calculate the speed of sound on a day when the air is at 27 °C, and the change in speed for each degree Celsius near 0 °C. **[2]**

c. Explain why Newton's assumption that sound travels through air at a constant temperature was wrong. **[2]**

d. Ankit says sound travels more slowly on a humid monsoon day than on a dry winter day at the same temperature, because the damp air is "heavier". Is he right? Justify your answer. **[2]**

Question 11 — 8 marks

A coil of resistance 40 Ω and inductive reactance 30 Ω is connected to a 220 V (rms), 50 Hz supply.

a. What is meant by the power factor of an a.c. circuit? Explain why it is 1 for a pure resistor and 0 for a pure inductor. **[2]**

b. Explain why a choke coil, rather than a resistor, is used to reduce the current in an a.c. circuit such as a fan's speed regulator. **[2]**

c. Calculate the impedance of the coil, the current, its power factor and the power it uses. **[2]**

d. Srijana says that adding a capacitor of the right size in series with the coil would increase the power drawn. Is she right? Justify your answer with a calculation. **[2]**

OR

A flat circular coil of 100 turns and radius 5.0 cm carries a current of 0.50 A.

a. State the Biot–Savart law, and use it to explain why the field at the center of a circular coil is proportional to the number of turns and to the current, and inversely proportional to the radius. **[2]**

b. Explain why the coil of a moving-coil galvanometer is placed in a radial magnetic field. **[2]**

c. Calculate the magnetic field at the center of the coil. **[2]**

d. To make a galvanometer more sensitive, Niraj rewinds its coil with twice as many turns of the same wire. Will its current sensitivity and its voltage sensitivity both double? Justify your answer. **[2]**

Question 12 — 8 marks

In an electron microscope, electrons are accelerated from rest through a potential difference, and behave as waves of a very short wavelength.

a. State de Broglie's hypothesis, and explain why it was called a dual hypothesis. **[2]**

b. Explain why the wave nature of electrons was confirmed by passing them through a crystal, and not through a ruled grating. **[2]**

c. Calculate the de Broglie wavelength of an electron accelerated through 150 V. **[2]**

d. If every moving body is a wave, why does a football of mass 0.45 kg kicked at 20 m/s never show diffraction when it passes through a goal? Justify your answer with a calculation. **[2]**