Grade 12 Physics Model Paper 1

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 11 and 12 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 and $e = 1.6 \times 10^{-19}$ C.

Group A Multiple choice — 11 marks

Question 1 — 11 × 1 = 11

Choose the correct option for each of the following questions.

a. What is the SI unit of angular momentum?

(i) kg m/s (ii) kg m²/s (iii) kg m²/s² (iv) N m

b. Water rises in a clean glass capillary tube, but mercury falls in it. Why?

(i) Water is denser than mercury.
(ii) The surface tension of water is greater than that of mercury.
(iii) The angle of contact of water with glass is less than 90°, and that of mercury is more than 90°.
(iv) Mercury does not wet any surface because it is a metal.

c. A load hung from a spring bobs up and down with a period of 0.8 s. The load is replaced by one four times as heavy. What is the new period?

(i) 0.2 s (ii) 0.4 s (iii) 1.6 s (iv) 3.2 s

d. An ideal gas expands isothermally and takes in 500 J of heat. How much work does it do?

(i) 0 J, because its temperature does not change
(ii) less than 500 J, because some heat raises its internal energy
(iii) 500 J, because its internal energy does not change
(iv) more than 500 J, because it also loses internal energy

e. What is the efficiency of a Carnot engine working between a source at 227 °C and a sink at 27 °C?

(i) 12% (ii) 40% (iii) 60% (iv) 88%

f. The siren of an ambulance sounds higher in pitch to a person on the roadside while the ambulance comes towards her. Why?

(i) The siren makes a higher frequency while the ambulance moves.
(ii) The sound travels faster through air when its source moves.
(iii) The waves in front of the moving siren are crowded together, so more of them reach her each second.
(iv) The amplitude of the sound grows as the ambulance comes closer.

g. In Young's double-slit experiment the fringes are 2.4 mm wide in air. The whole apparatus is then put under water, of refractive index 4/3, with nothing else changed. What is the new fringe width?

(i) 3.2 mm (ii) 2.4 mm (iii) 1.8 mm (iv) 1.35 mm

h. An electron enters a uniform magnetic field moving exactly along the field lines. What path does it follow in the field?

(i) a circle (ii) a helix
(iii) a parabola (iv) a straight line, at the same speed

i. Which of these is true of a diamagnetic substance such as bismuth?

(i) It is strongly attracted by a magnet and keeps some magnetism afterwards.
(ii) Its susceptibility is small and positive.
(iii) Its susceptibility is small and negative, so it is weakly repelled by a magnet.
(iv) Its relative permeability is much greater than 1.

j. What is the reactance of a pure inductor of 0.1 H on Nepal's 50 Hz a.c. mains?

(i) 5 Ω (ii) 31.4 Ω (iii) 0.03 Ω (iv) 314 Ω

k. What is the least energy needed to just remove an electron from the surface of a metal called?

(i) the stopping potential (ii) the threshold frequency
(iii) the ionization energy (iv) the work function

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

Question 2 — 5 marks

At the Dashain fair in Bhaktapur, a ring and a solid disc of the same mass and the same radius are let go together from the top of the same sloping plank, and both roll down without slipping.

a. Define angular momentum. **[1]**

b. A diver leaving the high board pulls her knees up to her chest and turns several somersaults, then straightens out just before she enters the water. Explain why she turns faster when she is tucked. **[2]**

c. Which reaches the bottom first, the ring or the disc? Give a reason. **[2]**

Question 3 — 5 marks

In a school laboratory in Biratnagar, a steel ball of radius 1.0 mm is dropped into a tall jar of glycerine. After a short time it falls steadily, taking 10 s to pass between two marks 10 cm apart. The density of steel is 8,000 kg/m³ and that of glycerine 1,250 kg/m³.

a. State Stokes' law. **[1]**

b. Calculate the coefficient of viscosity of the glycerine. **[2]**

c. Pratiksha then drops a steel ball of half the radius into the same glycerine. She expects it to take 20 s to fall between the marks. Is she right? Explain, and find the time it really takes. **[2]**

OR

A brass bob hangs from a light string 2.45 m long from a beam in the hall of a school in Pokhara, and swings through small angles as a simple pendulum.

a. Define simple harmonic motion. **[1]**

b. Calculate the period of this pendulum. **[2]**

c. A pendulum clock keeps correct time in Pokhara. A climber carries it to a high camp on Everest, where g is a little smaller. Will the clock gain time or lose time there? Give a reason. **[2]**

Question 4 — 5 marks

A bicycle pump is a cylinder of air closed by a piston; pushing the handle in quickly squeezes the air before it can pass into the tyre.

a. State the first law of thermodynamics. **[1]**

b. Explain why the molar specific heat capacity of a gas at constant pressure, C_P, is greater than that at constant volume, C_V. **[2]**

c. For nitrogen, $C_V = 20.8$ J/(mol K). Taking $R = 8.3$ J/(mol K), find C_P for nitrogen. **[1]**

d. Why does the air in the pump become warm when the handle is pushed in quickly? **[1]**

Question 5 — 5 marks

Sujan looks at an orange laser beam of wavelength 600 nm through a diffraction grating that has 5,000 lines per centimeter, held at right angles to the beam.

a. What is meant by the grating element of a diffraction grating? **[1]**

b. Calculate the angle at which he sees the first-order bright line. **[2]**

c. Sujan says he will be able to see bright lines up to the fourth order on each side. Is he right? Justify your answer. **[2]**

Question 6 — 5 marks

Anjali wants to find the resistance of a short piece of nichrome wire, which she thinks is about 5 Ω, with a meter bridge, a resistance box, a galvanometer, a cell and a key.

a. State the principle of the Wheatstone bridge. **[1]**

b. Her first try, with 1 Ω taken out of the resistance box, puts the balance point far from the middle, near one end of the wire. What should she change, and why? **[1]**

c. Explain how she can find the resistance of the nichrome wire with the meter bridge. With 4 Ω in the resistance box, in the right gap, and the wire in the left gap, the balance point is 55.0 cm from the left end. Find the resistance of the wire. **[3]**

Question 7 — 5 marks

Dawa drops a strong, small cylindrical magnet down a vertical copper pipe held upright. It takes several seconds to come out of the bottom, though a piece of unmagnetized steel of the same size falls through in a moment. Copper is not attracted by a magnet.

a. State Faraday's laws of electromagnetic induction. **[2]**

b. Explain why the iron core of a transformer is made of thin sheets insulated from one another. **[1]**

c. Explain why the magnet falls so slowly through the copper pipe, and what would happen if the pipe had a narrow slit cut along its whole length. **[2]**

Question 8 — 5 marks

Iodine-131, a beta emitter with a half-life of 8.0 days, is used in hospitals in Kathmandu to find out how well a patient's thyroid gland is working, and to treat it.

a. A sample of iodine-131 has an activity of 3.2 MBq when it reaches the hospital. Calculate its decay constant, and how long it takes for its activity to fall to 0.4 MBq. **[3]**

b. Uranium-238 has a half-life of 4.5 billion years. Explain why a radioactive isotope used inside a patient's body must have a short half-life like iodine-131's, not a long one like uranium-238's. **[2]**

Question 9 — 5 marks

An X-ray machine at a district hospital works with a Coolidge tube at 31 kV.

a. Write any three properties of X-rays. **[3]**

b. Calculate the shortest wavelength of the X-rays produced by the tube. **[2]**

OR

A silicon diode in a phone charger is a p–n junction.

a. Describe how the depletion layer and the potential barrier form at a p–n junction. **[3]**

b. The output of an OR gate is fed into a NOT gate. Write the truth table of the combination and name the single gate it is equal to. **[2]**

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

Question 10 — 8 marks

The main string of a sarangi in Pokhara is 0.60 m long between its fixed ends, has a mass of 5.0 g per meter, and is stretched with a tension of 72 N.

a. Calculate the frequency of the fundamental note of the string. **[2]**

b. The player wants the same string to sound 150 Hz. To what tension must the string be tightened? **[2]**

c. With the tension back at 72 N, the player touches the string lightly at its exact middle and bows it. Explain what note is heard now. **[2]**

d. Utsab fits a second string of the same metal and the same length, but with twice the diameter, and stretches it to the same 72 N. He says its fundamental will be $100/\sqrt{2} \approx 71$ Hz, because the thicker string is twice as heavy. Do you agree? Justify your answer. **[2]**

Question 11 — 8 marks

A series circuit of a 30 Ω resistor, an inductor and a capacitor is connected to a 200 V (rms), 50 Hz supply. At this frequency the inductive reactance is 80 Ω and the capacitive reactance 40 Ω.

a. Is the circuit more inductive or more capacitive? Explain whether the current leads or lags the supply voltage, and by what angle. **[2]**

b. Calculate the impedance of the circuit and show that the rms current is 4 A. **[2]**

c. With this current of 4 A, the voltages across the resistor, the inductor and the capacitor are 120 V, 320 V and 160 V. Shishir adds them to 600 V, much more than the 200 V supply. Explain, with a phasor diagram, why they still add up to 200 V. **[2]**

d. To make the circuit take the most power from the same supply, should the capacitor be replaced by a larger or a smaller one? Justify your answer with the capacitance needed. **[2]**

OR

Pasang has a moving-coil galvanometer of resistance 99 Ω that gives a full-scale deflection for a current of 1 mA.

a. Explain why a galvanometer is converted into an ammeter by connecting a low resistance in parallel with it. **[2]**

b. Explain why a voltmeter must have a very high resistance. **[2]**

c. Calculate the shunt needed to make the galvanometer an ammeter reading up to 100 mA. **[2]**

d. To make a voltmeter reading up to 10 V, Pasang's friend says he should just put a 10 kΩ resistor in series with the galvanometer. Is the friend exactly right? Find the resistance really needed, and judge whether the friend's resistor would do. **[2]**

Question 12 — 8 marks

In an experiment on the photoelectric effect, light of different frequencies falls on a metal plate, and the stopping potential V_0 is measured for each:

Frequency f (× 10^{14} Hz)	6.0	7.0	8.0	9.0	10.0
Stopping potential V_0 (V)	0.48	0.89	1.30	1.71	2.13

a. No electrons are emitted from this plate by light below a certain frequency, however bright the light is. Explain why. **[2]**

b. Explain why the stopping potential does not change when the intensity of the light is increased at the same frequency. **[2]**

c. Use the results to find Planck's constant. **[2]**

d. Find the work function of the metal in electron volts, and decide whether red light of wavelength 650 nm can eject electrons from it. **[2]**

OR

The energy of the electron in the nth orbit of a hydrogen atom is $E_n = -\frac{13.6}{n^2}$ eV.

a. Explain why hot hydrogen gas gives a spectrum of separate bright lines and not a continuous spectrum. **[2]**

b. Explain why the energies of the electron in the atom are negative. **[2]**

c. Calculate the wavelength of the light emitted when the electron jumps from the n = 3 level to the n = 2 level. **[2]**

d. Hydrogen atoms in their ground state are hit by photons of 10.2 eV, 11.0 eV and 12.75 eV. Which of these photons can be absorbed? Justify your answer. **[2]**