Grade 11 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 2077, Grade 11 Physics (Phy. 101); 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 NEB's Grade 11 Physics paper (Phy. 101): 75 marks in 3 hours. Group A is one question of 11 multiple-choice items; groups B and C have questions of two or three parts, with the marks of each part. Questions 2 and 6 in group B and Question 11 in group C have an OR question: answer either one. Take $g = 9.8\ \mathrm{m/s^2}$ unless a question gives another value. Write your answers on paper as in the exam hall, then tap your choice in group A, open each other part's answer and give yourself the marks its scheme allows.

Group A Multiple choice — 11 marks

Question 1 — 11 × 1 = 11

Choose the correct option for each of the following questions.

a. The newton is a derived unit. What is it in SI base units?

(i) kg m s^{-1} (ii) kg m s^{-2} (iii) kg m^2 s^{-2} (iv) kg m^{-1} s^{-2}

b. From the top of a wall, Rupesh drops one stone and, at the same moment, throws an identical stone horizontally. Ignore air resistance. Which reaches the ground first?

(i) The dropped stone
(ii) The thrown stone
(iii) Both reach the ground at the same time.
(iv) It depends on how fast the second stone is thrown.

c. A packet of sugar weighed on a spring balance at the poles reads slightly more than at the equator. Why?

(i) Its mass is larger at the poles.
(ii) The acceleration due to gravity is larger at the poles.
(iii) Air pressure is larger at the poles.
(iv) The Earth's magnetic field is stronger at the poles.

d. A stone tied to a string is whirled in a horizontal circle. The string suddenly breaks. In which direction does the stone fly off?

(i) Towards the center of the circle
(ii) Straight outwards, along the radius
(iii) Along the tangent to the circle at the point where it was
(iv) On round the circle, slowing down

e. The momentum of a body is doubled, its mass staying the same. By what factor does its kinetic energy change?

(i) It stays the same. (ii) It doubles.
(iii) It becomes 4 times as much. (iv) It becomes half as much.

f. How is the focal length f of a spherical mirror of small aperture related to its radius of curvature R?

(i) $f = R$ (ii) $f = R/2$
(iii) $f = 2R$ (iv) $f = R/4$

g. Why are convex mirrors used as the rear-view mirrors of vehicles?

(i) They always form real, magnified images.
(ii) They always form erect, diminished images and show a wide field of view.
(iii) They form erect images of the same size as the object.
(iv) They form images only of objects close to them.

h. A coin lies at the bottom of a bucket of water 12 cm deep. The refractive index of water is 4/3. How deep does the coin appear, looking straight down?

(i) 16 cm (ii) 12 cm (iii) 9 cm (iv) 3 cm

i. A biconvex lens is made of glass of refractive index 1.5, and both its faces have a radius of curvature of 20 cm. What is its focal length?

(i) 10 cm (ii) 20 cm (iii) 40 cm (iv) 30 cm

j. Two point charges repel each other with a force F. One charge is doubled and the distance between them is halved. What is the force now?

(i) F (ii) $2F$ (iii) $4F$ (iv) $8F$

k. What do isotopes of an element have in common?

(i) The same number of protons (ii) The same number of neutrons
(iii) The same mass number (iv) The same number of nucleons

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

Question 2 — 5 marks

A ferry boat on the Narayani can move at 4.0 m/s in still water. The river is 80 m wide and flows at 3.0 m/s. Its boatman, Gaurav, first points the boat straight across.

a. State the parallelogram law of vector addition. What is meant by the resolution of a vector? **[2]**

b. Find the boat's resultant velocity, the time it takes to cross, and how far downstream it lands. **[2]**

c. In which direction should Gaurav point the boat to land exactly opposite his starting point? **[1]**

OR

Diya (30 kg) sits on a see-saw in a park in Dhangadhi, 1.5 m from its pivot. Her brother Rohan (45 kg) sits on the other side.

a. Define the moment of a force (torque). State the principle of moments. **[2]**

b. How far from the pivot must Rohan sit for the see-saw to balance? What is the upward force of the pivot on the see-saw? (Ignore the weight of the plank, which is balanced at the pivot.) **[2]**

c. Once balanced, both children move 0.5 m farther from the pivot. Diya says the see-saw will still balance, since both moved by the same amount. Is she right? Give a reason. **[1]**

Question 3 — 5 marks

On a hot day in Nepalgunj, Salim cools 0.50 kg of lemonade (take it as water) at 30 °C by dropping in ice at 0 °C. (Specific heat capacity of water = 4200 J/(kg K), specific latent heat of fusion of ice = 3.36×10^5 J/kg; ignore the glass and any heat from the air.)

a. Why does a scald from steam at 100 °C hurt much more than one from boiling water at 100 °C? **[1]**

b. What mass of ice must he add to cool the lemonade to 10 °C? **[3]**

c. Would 0.11 kg of water at 0 °C cool the lemonade as much as 0.11 kg of ice at 0 °C? Give a reason. **[1]**

Question 4 — 5 marks

A cylinder of oxygen at a health post in Mustang is at 27 °C. (Molar gas constant $R = 8.31$ J/(mol K), molar mass of oxygen = 0.032 kg/mol.)

a. State Boyle's law and Charles's law. What is an ideal gas? **[3]**

b. Calculate the root mean square speed of the oxygen molecules. To what temperature must the gas be heated for this speed to double? **[2]**

Question 5 — 5 marks

Smriti fills a glass flask to the brim with 500 cm³ of mercury at 20 °C and heats it to 100 °C. (Real cubical expansivity of mercury = $1.8 \times 10^{-4}\ \mathrm{K}^{-1}$, cubical expansivity of glass = $2.7 \times 10^{-5}\ \mathrm{K}^{-1}$.)

a. Define the coefficient of cubical expansion (cubical expansivity) of a substance. **[1]**

b. How much mercury overflows from the flask? **[3]**

c. Smriti says that if the flask were made of a material that expanded exactly as much as mercury, no mercury would overflow, and if it expanded more than mercury, the level would fall below the brim. Is she right? Give a reason. **[1]**

Question 6 — 5 marks

Kriti is designing an achromatic doublet: a convex lens of crown glass in contact with a concave lens of flint glass.

a. Define angular dispersion and dispersive power. **[2]**

b. Why is a single lens not free from chromatic aberration? **[1]**

c. The dispersive powers of the crown and flint glass are 0.020 and 0.040, and the convex lens has a focal length of 20 cm. Find the focal length the concave lens must have, and the focal length of the doublet. **[2]**

OR

A ray of light in air meets a glass block at an angle of incidence of 30°. Bhumika measures the angle of refraction. (Refractive index of the glass = 1.5, speed of light in air = 3.0×10^{8} m/s.)

a. State the two laws of refraction of light. **[2]**

b. A straight pencil dipped at a slant into a glass of water looks bent at the surface. Why? **[1]**

c. Find the angle of refraction and the speed of light in the glass. **[2]**

Question 7 — 5 marks

Two small charges are fixed 40 cm apart in air: $+9.0$ nC at A and -3.0 nC at B. Simran studies the potential along the line between them. ($k = 9.0 \times 10^{9}$ N m²/C².)

a. What is an equipotential surface? Why is no work done in moving a charge along one, and how are the field lines placed relative to it? **[2]**

b. Find the potential at the midpoint of AB and the work needed to bring a charge of $+1.0$ nC there from infinity. Is there a point between A and B where the potential is zero? If so, find it. **[3]**

Question 8 — 5 marks

In a hydrogen atom, the electron and the proton are about 5.3×10^{-11} m apart. Mingma compares the electric and gravitational forces between them. ($e = 1.6 \times 10^{-19}$ C, $k = 9.0 \times 10^{9}$ N m²/C², $G = 6.67 \times 10^{-11}$ N m²/kg², mass of electron = 9.1×10^{-31} kg, mass of proton = 1.67×10^{-27} kg.)

a. State Coulomb's law. What is the relative permittivity (dielectric constant) of a medium? **[2]**

b. Calculate the electric force and the gravitational force between the electron and the proton, and the ratio of the two. What does the ratio tell you about which force holds atoms together? **[3]**

Question 9 — 5 marks

In a circuit Sakshi builds, a 3.0 Ω and a 6.0 Ω resistor are joined in parallel, and the pair is joined in series with a 4.0 Ω resistor across a 12 V supply of negligible internal resistance.

a. Why are the lights and appliances in a house connected in parallel and not in series? **[1]**

b. Find the total resistance and the current from the supply. **[2]**

c. Find the power in each resistor. Which one turns the most electrical energy into heat, and why? **[2]**

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

Question 10 — 8 marks

A bus leaves the Gongabu bus park from rest. It speeds up at 2.0 m/s² for 10 s, then runs at a steady speed for 30 s, then brakes evenly to a stop in 8.0 s. Its driver is Sushant.

a. What do the slope and the area of a velocity–time graph tell you? Use the graph of uniformly accelerated motion to derive $v = u + at$ and $s = ut + \tfrac{1}{2}at^2$. **[3]**

b. Find the bus's top speed and the total distance it travels. **[2]**

c. At 20 m/s Sushant sees a cow on the road 70 m ahead. He takes 0.50 s to react, and then brakes as before. Does the bus stop in time? If not, find the deceleration it would need. **[3]**

Question 11 — 8 marks

A steel wire 3.0 m long with a cross-sectional area of 2.0 mm² holds a sign outside Prakriti's shop in Butwal. The sign pulls on it with 400 N. (Young's modulus of steel = 2.0×10^{11} Pa.)

a. Describe a stress–strain curve for a metal wire stretched until it breaks, naming the elastic limit and the yield point. **[2]**

b. Calculate the stress, the strain and the extension of the wire. **[3]**

c. Show that the elastic energy stored per unit volume of a stretched wire is $\tfrac{1}{2} \times \text{stress} \times \text{strain}$, and find it for this wire. The Poisson's ratio of steel is 0.30: by what fraction does the wire's diameter decrease? **[3]**

OR

A forest guard in Bardiya fires a rifle of mass 4.0 kg in a training exercise. The bullet, of mass 20 g, leaves at 400 m/s.

a. State the principle of conservation of linear momentum, and use it to explain why a gun recoils. **[2]**

b. Calculate the recoil speed of the rifle and the kinetic energies of the bullet and the rifle. **[3]**

c. The bullet and the rifle have equal momenta. Explain why the bullet has 200 times as much kinetic energy. Why does the guard hold the rifle tightly against his shoulder? Find the recoil speed if he (60 kg) and the rifle move back together. **[3]**

Question 12 — 8 marks

The energy levels of the hydrogen atom are $E_n = -\dfrac{13.6}{n^2}$ eV. ($h = 6.63 \times 10^{-34}$ J s, $c = 3.0 \times 10^{8}$ m/s, 1 eV = 1.6×10^{-19} J.)

a. Explain how the energy levels of single atoms become bands in a solid. How does band theory explain the difference between a conductor, an insulator and a semiconductor? **[3]**

b. An electron in a hydrogen atom drops from level 4 to level 2. Calculate the energy of the photon given out, in eV and in joules, and its wavelength. **[3]**

c. Can a photon of this light lift an electron across the band gap of silicon (1.1 eV)? Of diamond (5.5 eV)? Use your answer to explain why diamond is transparent but silicon is not. **[2]**