S5 Physics Practice Paper: Kinematics, Forces, Energy, Momentum, Waves and Electricity

S5 Physics | Time allowed: 90 minutes | Total: 100 marks | 24 questions

A. Kinematics (18 marks)

In the following questions air resistance is negligible and g = 10 m s^{-2}.

1. A car accelerates uniformly from rest to 20 m s^{-1} in 8 s. Find its acceleration. (3 marks)

> **Answer:** a = (v – u) / t = (20 – 0) / 8 = 2.5 m s^{-2}.

2. For the same car, find the distance travelled in these 8 s. (4 marks)

> **Answer:** s = ½(u + v)t = ½(0 + 20)(8) = 80 m (check with s = ut + ½at^2 = 80 m).

3. A stone is dropped from rest at a height of 45 m. Find the time it takes to reach the ground. (5 marks)

> **Answer:** t = √(2h / g) = √(2 × 45 / 10) = 3 s.

4. For the same stone, find its speed on landing and explain why the answer does not depend on its mass. (6 marks)

> **Answer:** v = gt = 10 × 3 = 30 m s^{-1} downwards. For free fall a = F / m = mg / m = g, so mass cancels and the speed is independent of mass.

B. Forces and Motion (17 marks)

Take g = 10 m s^{-2}.

5. A 4 kg block rests on a rough horizontal table. The coefficient of friction is 0.25. Find the friction acting on the block. (4 marks)

> **Answer:** f = μmg = 0.25 × 4 × 10 = 10 N.

6. A horizontal force of 18 N now pulls the block. Find its acceleration. (4 marks)

> **Answer:** Net force = 18 – 10 = 8 N; a = net force / m = 8 / 4 = 2 m s^{-2}.

7. The same block is placed on a smooth incline of 30°. Find its acceleration down the slope. (4 marks)

> **Answer:** Component along slope = mg sin30° = 4 × 10 × 0.5 = 20 N; a = 20 / 4 = 4 m s^{-2}.

8. For the block on the incline, find the normal force from the slope and state its reaction pair. (5 marks)

> **Answer:** N = mg cos30° = 4 × 10 × 0.866 = 34.6 N. Its reaction is the force the block exerts on the slope, equal in magnitude and opposite in direction.

C. Work, Energy and Power (16 marks)

Take g = 10 m s^{-2}.

9. A force of 60 N at 30° above the horizontal pulls a sledge 5 m along level ground. Find the work done by the force. (4 marks)

> **Answer:** W = Fs cosθ = 60 × 5 × cos30° = 259.8 J (about 260 J).

10. 20 kg of water is lifted through 1.5 m in 5 s. Find the power delivered. (4 marks)

> **Answer:** W = mgh = 20 × 10 × 1.5 = 300 J; P = W / t = 300 / 5 = 60 W.

11. A 1200 kg car travels at 72 km/h. Find its kinetic energy. (4 marks)

> **Answer:** 72 km/h = 20 m s^{-1}; KE = ½mv^2 = ½ × 1200 × 20^2 = 2.4 × 10^5 J.

12. The car brakes to a stop and all its kinetic energy becomes heat. If the average resistance is 6000 N, find the braking distance. (4 marks)

> **Answer:** Fs = KE; s = 2.4 × 10^5 / 6000 = 40 m.

D. Momentum and Collisions (16 marks)

Take the direction away from the wall as positive.

13. A 0.4 kg ball hits a wall at 6 m s^{-1} and rebounds at 4 m s^{-1}. Find its change in momentum. (4 marks)

> **Answer:** Δp = m(v – u) = 0.4 × (4 – (–6)) = 4 N s, directed away from the wall.

14. A 2 kg toy car at 3 m s^{-1} hits a stationary 1 kg toy car and they stick together. Find the common velocity. (4 marks)

> **Answer:** Momentum is conserved: 2 × 3 = (2 + 1) × v; v = 6 / 3 = 2 m s^{-1}.

15. For the collision above, find the kinetic energy lost. (4 marks)

> **Answer:** KE before = ½ × 2 × 3^2 = 9 J; KE after = ½ × 3 × 2^2 = 6 J; loss = 3 J.

16. Explain why momentum is conserved in this collision but kinetic energy is not. (4 marks)

> **Answer:** External forces on the system are negligible, and momentum is a vector, so total momentum is conserved; however part of the kinetic energy becomes heat, sound and deformation energy.

E. Waves and Light (17 marks)

Take the speed of sound in air as 340 m s^{-1} and the speed of light in vacuum as 3.0 × 10^8 m s^{-1}.

17. A sound wave of frequency 170 Hz travels at 340 m s^{-1} in air. Find its wavelength. (5 marks)

> **Answer:** λ = v / f = 340 / 170 = 2 m.

18. Light in air strikes glass (refractive index 1.5) at an angle of incidence of 45°. Find the angle of refraction. (4 marks)

> **Answer:** sin r = sin45° / 1.5 = 0.4714; r = 28.1°.

19. For the light entering the glass, how do its speed and wavelength change, and does its frequency change? (4 marks)

> **Answer:** $v = c / n = 3.0 \times 10^8 / 1.5 = 2.0 \times 10^8$ m s^{-1}; the wavelength becomes 1 / 1.5 (about 0.67) of its value in air; the frequency stays the same.

20. State the two conditions for total internal reflection. (4 marks)

> **Answer:** Light must travel from an optically denser to an optically less dense medium, and the angle of incidence must exceed the critical angle C, where sin C = 1 / n.

F. Circuits and Electricity Cost (16 marks)

The circuits below use a 12 V battery of negligible internal resistance.

21. A 6 Ω resistor and a 3 Ω resistor are connected in parallel. Find the equivalent resistance. (4 marks)

> **Answer:** 1 / R = 1 / 6 + 1 / 3 = 0.5; R = 2 Ω.

22. A 4 Ω resistor is now in series with that parallel combination, across the 12 V battery. Find the total current. (4 marks)

> **Answer:** R total = 2 + 4 = 6 Ω; I = V / R = 12 / 6 = 2 A.

23. Find the power delivered by the battery and the power dissipated in the 4 Ω resistor. (4 marks)

> **Answer:** P = VI = 12 × 2 = 24 W; P for 4 Ω = $I^2R = 2^2 \times 4 = 16$ W.

24. A 2000 W water heater is used 3 hours a day for 30 days. If electricity costs $1.2 per kWh, find the total cost. (4 marks)

> **Answer:** Energy = 2 kW × 3 h × 30 = 180 kWh; cost = 180 × 1.2 = $216.00.