# S4 Physics Practice Paper 1 | kinematics, forces, momentum, circuits and specific heat

## Senior Secondary Physics

S4 Physics practice paper with answers: kinematics equations, Newton second law with friction, work and energy, momentum and collisions, circuits, specific heat capacity.

## 1. Uniformly accelerated motion and graphs (16 marks)

*Take g = 10 m s^-2 and give answers to one decimal place unless stated.*

| # | Question | Answer and marking notes |
|---|---|---|
| 1 | (a) A car starts from rest and accelerates uniformly at 2.5 m s^-2 for 8 s. Find the velocity at the end of 8 s and the displacement in that time. | Answer: v = u + at = 0 + 2.5 x 8 = 20.0 m/s; s = ut + 0.5 a t squared = 0.5 x 2.5 x 64 = 80.0 m. |
| 2 | (b) A car travelling at 15 m/s brakes uniformly and stops in 40 m. Find the acceleration and the braking time. | Answer: v squared = u squared + 2as gives 0 = 225 + 80a, so a = -2.5 m/s^2 opposite to the motion; t = (v - u) / a = (5 - 15) / (-2.5) = 4.0 s. |
| 3 | (c) A ball falls freely from a 45 m platform, ignoring air resistance. Find the time of fall and the speed on landing. | Answer: s = 0.5 g t squared gives 45 = 5 t squared, so t = 3.0 s; v = g t = 10 x 3 = 30.0 m/s. |
| 4 | (d) State what the gradient of a displacement-time graph and the gradient of a velocity-time graph represent, and explain the meaning of the area under a velocity-time graph. | Answer: the gradient of a displacement-time graph is velocity; the gradient of a velocity-time graph is acceleration; the area under a velocity-time graph is the displacement in that interval. |

## 2. Newton second law and friction (18 marks)

*Take g = 10 m s^-2 and show the force analysis.*

| # | Question | Answer and marking notes |
|---|---|---|
| 5 | (a) An 8 kg object on a horizontal surface is pulled by a 36 N horizontal force against 12 N of friction. Find its acceleration. | Answer: net force = 36 - 12 = 24 N; a = F / m = 24 / 8 = 3.0 m/s^2. |
| 6 | (b) A 5 kg object slides down a frictionless 30 degree incline. Find its acceleration; if friction on the incline is 6 N, find the new acceleration. | Answer: without friction a = g sin 30 = 5.0 m/s^2; with friction a = (m g sin 30 - f) / m = (25 - 6) / 5 = 3.8 m/s^2. |
| 7 | (c) A 60 kg person stands on a scale in a lift. What does the scale read when the lift accelerates upward at 2 m/s^2, and when it accelerates downward at 2 m/s^2? | Answer: accelerating up, R = m (g + a) = 60 x 12 = 720 N; accelerating down, R = m (g - a) = 60 x 8 = 480 N. |

| # | Question | Answer and marking notes |
|---|---|---|
| **8** | (d) Use inertia to explain why a passenger lurches forward when a car brakes sharply, and state the function of a seat belt. | Answer: the passenger keeps the original state of motion, so while the cabin slows the upper body continues at the old speed and lurches forward; the seat belt exerts a backward force, lengthens the deceleration time and reduces the acceleration and impact force, and prevents the passenger from striking the interior or being thrown out. |

## 3. Work, energy and power (16 marks)

*Take g = 10 m s^-2 and give units.*

| # | Question | Answer and marking notes |
|---|---|---|
| **9** | (a) A 50 N horizontal force moves an object 12 m in 8 s. Find the work done and the average power. | Answer: W = F s = 50 x 12 = 600 J; P = W / t = 600 / 8 = 75.0 W. |
| **10** | (b) A 2 kg ball falls freely from 5 m. Find its speed on reaching the ground, ignoring air resistance. | Answer: m g h = 0.5 m v squared gives v = square root of (2 g h) = square root of 100 = 10.0 m/s, independent of mass. |
| **11** | (c) A machine takes in 2,500 J and is 80 per cent efficient. Find the useful output and the energy wasted as heat and sound. | Answer: useful output = 2,500 x 0.8 = 2000 J; wasted = 2,500 - 2,000 = 500 J. |
| **12** | (d) Explain why mechanical energy is not conserved when a body slides down a real incline, and state where the energy goes. | Answer: friction does negative work, so part of the gravitational potential and kinetic energy becomes heat and sound in the surface and the surrounding air; total energy is still conserved once these losses are counted. |

## 4. Momentum and collisions (18 marks)

*Give momentum in kg m s^-1 and energy in joules.*

| # | Question | Answer and marking notes |
|---|---|---|
| **13** | (a) A car of mass 1,200 kg travels at 15 m/s. Find its momentum. | Answer: p = m v = 1,200 x 15 = 18000 kg m/s. |
| **14** | (b) A 0.5 kg clay ball at 4 m/s hits a stationary 1.5 kg block and sticks to it. Find the common velocity and the kinetic energy lost. | Answer: momentum is conserved, 0.5 x 4 = 2.0 x v, so v = 1.0 m/s; kinetic energy before = 4.0 J and after = 1.0 J, a loss of 3.0 J, which is a perfectly inelastic collision. |
| **15** | (c) An athlete of mass 60 kg holds a 4 kg rifle and fires a 0.02 kg bullet horizontally at 400 m/s. Find the recoil speed of the athlete. | Answer: total momentum is zero, 0.02 x 400 = 60 x v, so v = 0.13 m/s in the direction opposite to the bullet. |

| # | Question | Answer and marking notes |
|---|---|---|
| **16** | (d) Use impulse F t = change in momentum to explain how an airbag reduces injury in a crash. | Answer: the change in momentum is fixed, and the airbag lengthens the collision time, so the average force falls; it also spreads the pressure over a larger area, reducing fractures and internal injury. |

## 5. Ohm law, series and parallel circuits, power (16 marks)

*Give currents to one decimal place and power as whole numbers.*

| # | Question | Answer and marking notes |
|---|---|---|
| **17** | (a) A 12 V supply is connected to 4 ohm and 6 ohm resistors in series. Find the total resistance, the current and the voltage across each resistor. | Answer: R = 4 + 6 = 10 ohm; I = 12 / 10 = 1.2 A; V across 4 ohm = 4.8 V and across 6 ohm = 7.2 V. |
| **18** | (b) The same 12 V supply is now connected to the two resistors in parallel. Find the equivalent resistance, the total current and the current in each branch. | Answer: R = 24 / 10 = 2.4 ohm; total current = 12 / 2.4 = 5.0 A; branch currents are 3.0 A and 2.0 A, whose sum equals the total. |
| **19** | (c) An electric kettle is rated 220 V, 2,000 W. Find the current; if it is used for half an hour, find the energy used in kWh and the cost at 1.2 dollars per kWh. | Answer: I = 2,000 / 220 = 9.1 A; energy = 2 kW x 0.5 h = 1.0 kWh; cost = 1 x 1.2 = 1.20 dollars. |
| **20** | (d) State one feature each of series and parallel circuits and explain why household appliances are connected in parallel. | Answer: in series the current is the same throughout and the supply voltage is shared; in parallel each branch has the full voltage and the total current is the sum of the branch currents. Household appliances are in parallel so each gets the full voltage and can be switched independently, and one faulty appliance does not stop the others. |

## 6. Specific heat capacity and latent heat (16 marks)

*Take the specific heat capacity of water as 4,200 J kg^-1 K^-1 and the latent heat of fusion of ice as 3.34 x 10^5 J kg^-1.*

| # | Question | Answer and marking notes |
|---|---|---|
| **21** | (a) How much energy is needed to heat 2 kg of water from 20 C to 70 C? | Answer: E = m c delta T = 2 x 4,200 x 50 = 420000 J, that is 4.2 x 10^5 J. |
| **22** | (b) A 1,500 W heater with no heat loss is used on the same 2 kg of water. How many seconds are needed? | Answer: t = E / P = 420,000 / 1,500 = 280 s, about 4.7 minutes. |
| **23** | (c) How much energy is needed to melt 0.5 kg of ice at 0 C completely and then warm the water to 20 C? | Answer: melting = 0.5 x 3.34 x 10^5 = 167000 J; warming = 0.5 x 4,200 x 20 = 42000 J; total = 209000 J. |

| # | Question | Answer and marking notes |
|---|---|---|
| **24** | (d) 0.3 kg of water at 80 C is mixed with 0.5 kg of water at 20 C, with no heat loss. Find the final temperature. | Answer: heat lost equals heat gained, 0.3 x (80 - T) = 0.5 x (T - 20), that is 24 - 0.3 T = 0.5 T - 10, so T = 42.5 C. |