S6 Physics Practice Paper: Mechanics and Motion, Circular Motion and Gravitation, Waves and Optics, Electricity and Magnetism, Thermal Physics, Atomic and Nuclear Physics

S6 | Physics | Time: 75 minutes | Total: 100 marks | 24 questions

Part 1 Mechanics and Motion

State the formula and unit used; take g = 9.81 m/s2.

1. A car accelerates uniformly from rest at 2.5 m/s2 for 8 s. Find (a) the final speed and (b) the distance travelled. [4]

Answer: (a) v = u + at = 0 + 2.5 x 8 = 20 m/s. (b) s = 0.5 x 2.5 x 8^2 = 80 m.

2. A stone is released from rest at a height of 45 m with air resistance ignored. Find the time of fall and the speed on landing. [4]

Answer: h = 0.5 g t^2, so t = sqrt(2 x 45 / 9.81) = 3.03 s; v = g t = 9.81 x 3.03 = 29.7 m/s downwards.

3. A box of mass 3.5 kg is pushed horizontally with 20 N while friction acts with 6 N. Find the acceleration of the box. [4]

Answer: Net force = 20 - 6 = 14 N; a = F/m = 14 / 3.5 = 4.0 m/s2.

4. A ball of mass 0.25 kg hits a wall at 12 m/s and rebounds at 9 m/s, contact time 0.05 s. Find the change in momentum and the average force from the wall. [4]

Answer: Taking away from the wall as positive: dp = m(v - u) = 0.25 x (9 + 12) = 5.25 kg m/s; F = dp/dt = 5.25 / 0.05 = 105 N away from the wall.

Part 2 Circular Motion and Gravitation

Take G = 6.67 x 10-11 N m2/kg2 and the mass of the Earth as 5.97 x 1024 kg.

5. An object moves uniformly on a circle of radius 0.8 m with period 0.4 s. Find the linear speed and the centripetal acceleration. [4]

Answer: v = 2 pi r / T = 2 pi x 0.8 / 0.4 = 12.6 m/s; a = v^2 / r = 12.6^2 / 0.8 = 197 m/s2.

6. A satellite orbits the Earth in a circular orbit of radius 7.0e+06 m. Find its orbital speed and period. [4]

Answer: v = sqrt(GM/r) = sqrt(6.67e-11 x 5.97e24 / 7.0e+06) = 7.54e+03 m/s; T = 2 pi r / v = 2 pi x 7.0e+06 / 7.54e+03 = 5831 s (about 97 minutes).

7. An astronaut of mass 60 kg stands on the Moon (g = 1.62 m/s2) and on the Earth. Find the weight in both places and explain whether the mass changes. [5]

Answer: Moon: W = mg = 60 x 1.62 = 97.2 N; Earth: W = 60 x 9.81 = 588.6 N. The mass stays 60 kg; only g differs, so the weight differs.

8. A car turns on a level road with radius 50 m. The maximum coefficient of static friction is 0.6. Find the maximum safe speed. [4]

Answer: Friction provides the centripetal force: mu m g = m v^2 / r, so v = sqrt(mu g r) = sqrt(0.6 x 9.81 x 50) = 17.2 m/s.

Part 3 Waves and Optics

Take the speed of sound as 340 m/s; angles are measured from the normal.

9. A sound wave has frequency 512 Hz and travels at 340 m/s in air. Find the wavelength and state how it changes if the frequency doubles. [4]

Answer: lambda = v / f = 340 / 512 = 0.664 m. If the frequency doubles at the same speed, the wavelength halves to 0.332 m.

10. In a double-slit experiment the slit separation is 0.5 mm, the screen is 2 m away and the third bright fringe is 7.2 mm from the centre. Find the wavelength. [4]

Answer: y = m lambda D / d, so lambda = y d / (m D) = (7.2e-3 x 0.5e-3) / (3 x 2) = 6.0e-07 m = 600 nm.

11. Light passes from air (n = 1.0) into glass of n = 1.5 at an angle of incidence of 45 degrees. Find the angle of refraction. [4]

Answer: n1 sin(theta1) = n2 sin(theta2), so sin(theta2) = sin45 / 1.5 = 0.4714 and theta2 = 28.1 degrees.

12. An object is placed 45 cm in front of a convex lens of focal length 15 cm. Find the image distance, the magnification and the nature of the image. [5]

Answer: 1/f = 1/u + 1/v, so 1/v = 1/15 - 1/45 and v = 22.5 cm (real image beyond the lens); m = v/u = 22.5 / 45 = 0.5, so it is inverted, diminished and real.

Part 4 Electricity and Magnetism

State the formulas; use W for power and J for energy.

13. 6 ohm and 12 ohm in parallel are joined in series with 4 ohm across a 12 V supply. Find the total resistance and the total current. [4]

Answer: Parallel part: 1/R = 1/6 + 1/12, so R_p = 4.0 ohm; total R = 4.0 + 4 = 8.0 ohm; I = V/R = 12 / 8.0 = 1.5 A.

14. A charge of 2e-06 C sits in a uniform field of 5e+04 V/m. Find the force on it and the work done by the field when it moves 0.2 m along the field. [4]

Answer: F = qE = 2e-06 x 5e+04 = 0.10 N; W = F d = 0.10 x 0.2 = 0.020 J.

15. A 20 ohm resistor carries 0.5 A for 5 minutes. Find the energy dissipated and the power. [4]

Answer: P = I^2 R = 0.5^2 x 20 = 5 W; E = P t = 5 x 300 = 1500 J.

16. An ideal transformer has 2400 primary turns and 120 secondary turns, a primary voltage of 240 V and a secondary current of 5.0 A. Find the secondary voltage and primary current. [5]

Answer: Vs/Vp = Ns/Np, so Vs = 240 x 120/2400 = 12 V; for an ideal transformer the powers are equal, so Ip = Is x Ns/Np = 5.0 x 120/2400 = 0.25 A.

Part 5 Thermal Physics

Take the specific heat capacity of water as 4200 J/(kg K) and the specific latent heat of fusion of ice as 3.34 x 105 J/kg.

17. 0.5 kg of water is heated from 20 C to 80 C. Find the heat required. [4]

Answer: Q = m c dT = 0.5 x 4200 x 60 = 126000 J = 126 kJ.

18. 2 kg of water is heated from 20 C to 100 C by a 1500 W heater with no heat loss. Find the time needed. [4]

Answer: E = m c dT = 2 x 4200 x 80 = 672000 J; t = E/P = 672000 / 1500 = 448 s (about 7.5 minutes).

19. 0.2 kg of ice at 0 C melts completely to water at 0 C. Find the heat absorbed and explain why the temperature does not change during melting. [4]

Answer: Q = m L = 0.2 x 3.34e+05 = 66800 J. The heat breaks the crystal structure (raising potential energy) rather than raising mean kinetic energy, so the temperature stays at 0 C.

20. An ideal gas at 300 K and 1.0e+05 Pa occupies 2.0e-03 m3. It is heated at constant pressure to 450 K. Find the new volume. [5]

Answer: At constant pressure V1/T1 = V2/T2, so V2 = V1 x T2/T1 = 2.0e-03 x 450/300 = 3.0e-03 m3.

Part 6 Atomic and Nuclear Physics

Take h = 6.63 x 10-34 J s, c = 3.0 x 108 m/s, 1 eV = 1.6 x 10-19 J and 1 u = 931.5 MeV.

21. A photon has a wavelength of 500 nm. Find its energy in J and in eV. [4]

Answer: E = hc/lambda = (6.63e-34 x 300000000.0) / 5.0e-07 = 3.98e-19 J = 2.49 eV.

22. A metal has a work function of 2.0 eV and is illuminated by the photons above. Find the maximum kinetic energy of the photoelectrons and state whether emission occurs. [4]

Answer: K_max = E - W = 2.49 - 2.0 = 0.49 eV. Since 2.49 eV exceeds 2.0 eV, photoelectric emission occurs.

23. A radionuclide has a half-life of 5 days and currently contains 8.0e+20 nuclei. Find the number remaining after 15 days. [4]

Answer: 15 days is 3 half-lives; N = N0 x (1/2)^n = 8.0e+20 x (1/2)^3 = 1.0e+20 nuclei.

24. A nuclear reaction has a mass defect of 0.002 u. Find the energy released in MeV and in J. [4]

Answer: E = 0.002 x 931.5 = 1.863 MeV = 1.863 x 1.6e-13 = 2.98e-13 J.
