S6 Physics Practice Paper (Set 3): circular motion and gravitation, simple harmonic motion, double-slit and grating interference, magnetic force and induced e.m.f., radioac

Level: S6 | Subject: Physics | Time: 75 min | Total: 100 marks | Items: 24

Question 1 Circular motion and gravitation

Take g = 9.81 m s^{-2} and GM = 3.99 × 10^{14} m^3 s^{-2} for the Earth. Give answers to 3 s.f.

1. A 1200 kg car rounds a flat curve of radius 50 m. The coefficient of static friction is 0.60. Find the maximum speed without skidding. (4 marks)

2. A satellite moves in a circular orbit of radius 7.0 × 10^6 m about the Earth's centre. Find its orbital speed. (4 marks)

3. For the same satellite, find its orbital period in minutes. (4 marks)

4. Find the gravitational field strength g′ at that orbit, and explain why astronauts feel weightless. (4 marks)

Question 2 Simple harmonic motion

A mass of 0.50 kg on a spring of force constant 20 N m^{-1} oscillates with amplitude 0.080 m.

5. Find the period of oscillation. (4 marks)

6. Find the maximum speed. (4 marks)

7. Find the maximum acceleration and state where it occurs. (4 marks)

8. When the displacement is 0.040 m, find the speed and the fraction of the total energy that is kinetic. (4 marks)

Question 3 Interference and diffraction of light

The monochromatic light used has wavelength 600 nm.

9. In a Young's double-slit experiment the slit separation is 0.50 mm and the screen is 2.0 m away. Find the fringe spacing. (4 marks)

10. If the screen is moved to 3.0 m, find the new fringe spacing. (4 marks)

11. A grating of 500 lines per mm replaces the double slit. Find the diffraction angle of the first-order maximum. (5 marks)

12. Find the highest order of maximum observable with this grating, and explain. (5 marks)

Question 4 Magnetic force and induced e.m.f.

Electron charge 1.6×10^{-19} C, electron mass 9.11×10^{-31} kg.

13. An electron enters a uniform 0.20 T field at 3.0×10^{6} m s^{-1} perpendicular to the field. Find the magnitude of the magnetic force on it. (4 marks)

14. Find the radius of the electron's circular path in the field. (5 marks)

15. A 0.40 m rod moves at 2.5 m s^{-1} perpendicular to a 0.50 T field. Find the induced e.m.f. across it. (4 marks)

16. If the rod is connected across a 2.5 Ω resistor, find the current and the power dissipated. (4 marks)

Question 5 Radioactivity and nuclear energy

Take 1 u = 931.5 MeV.

17. A sample has initial activity 6400 Bq and half-life 8 days. Find the activity after 24 days. (4 marks)

18. How long does the same sample take to fall to 400 Bq? (4 marks)

19. A nuclear reaction has a mass defect of 0.0030 u. Find the energy released in MeV. (5 marks)

20. Write the β^- decay equation of carbon-14 and identify the products. (4 marks)

Question 6 Power, efficiency and ideal gas

Take R = 8.31 J mol^{-1} K^{-1} and $k = 1.38 \times 10^{-23}$ J K^{-1}.

21. A motor with input power 2.0 kW raises a 150 kg load at a steady 0.80 m s^{-1}. Find its efficiency. (4 marks)

22. 2.0 mol of ideal gas occupies 0.050 m^3 at 300 K. Find its pressure. (4 marks)

23. If it is heated to 450 K at constant volume, find the new pressure. (4 marks)

24. Find the mean translational kinetic energy of a gas molecule at 450 K. (4 marks)
