

Orbits, escape speed and gravitational energy

AP Physics C (Mechanics and E&M, calculus-based) · Test

Name: _____ Date: _____ Class: _____ Mark: ____ / 20

This test covers gravitational potential energy, circular and elliptical orbits and escape speed in the style of AP Physics C: Mechanics. Show each step, use calculus where asked and give units. Take $G = 6.67 \times 10^{-11} \text{ N m}^2/\text{kg}^2$ and the data given. The total is 20 marks.

Level: AP Physics C (Mechanics and E&M, calculus-based) · **Curriculum:** AP PC:M Unit 7

Time: 45 minutes · 8 questions · Total: 20 marks · Calculator allowed

Question 1 Field strength (2 marks)

Calculate the gravitational field strength at a distance of $3R$ from Earth's centre, where $R = 6.37 \times 10^6 \text{ m}$, given that $g = 9.81 \text{ m/s}^2$ at the surface.

Question 2 Low Earth orbit (3 marks)

A satellite orbits 600 km above Earth ($R = 6.37 \times 10^6 \text{ m}$, $GM = 3.98 \times 10^{14} \text{ N m}^2/\text{kg}^2$).

- Write the equation linking gravity and centripetal force. (1 mark)
- Calculate the orbital speed. (1 mark)
- Calculate the period. (1 mark)

Question 3 Effect of drag (2 marks)

Explain why a satellite in a low circular orbit speeds up as air drag slowly lowers it.

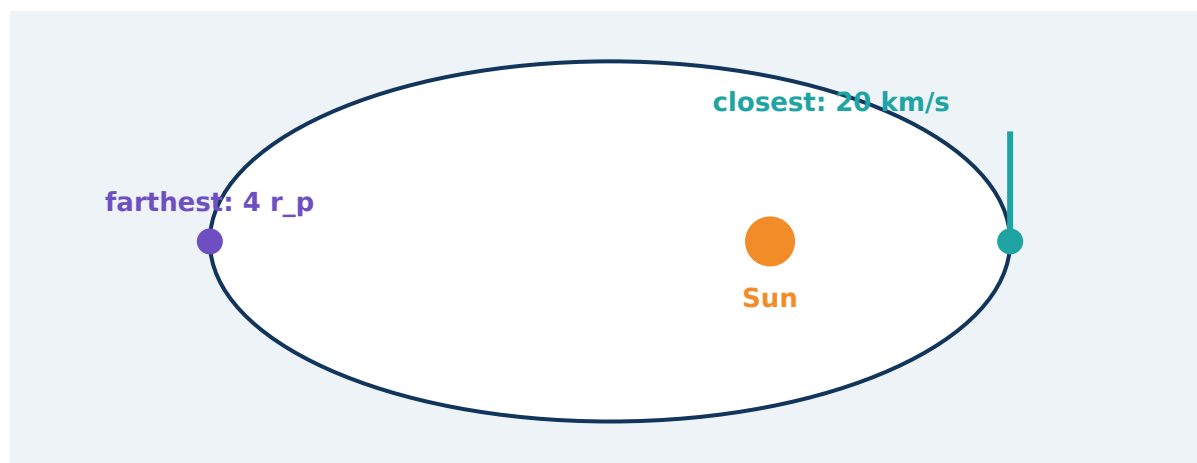
Question 4 Escape from the Moon (3 marks)

Derive and calculate the escape speed from the Moon ($M = 7.35 \times 10^{22} \text{ kg}$, $R = 1.74 \times 10^6 \text{ m}$, $G = 6.67 \times 10^{-11} \text{ N m}^2/\text{kg}^2$).

Question 5 Energies of an orbit (3 marks)

A satellite of mass 800 kg is in a circular orbit of radius $1.2 \times 10^7 \text{ m}$. Calculate (a) its kinetic energy, (b) its potential energy, (c) its total energy. Use $GM = 3.98 \times 10^{14}$.

Question 6 Comet speeds (3 marks)



Question 6: speed at the two extremes of the orbit.

A comet moves at 20 km/s at its closest point to the Sun (distance r_p). Its farthest point is $4r_p$ from the Sun (figure). Explain why the speed differs and calculate the speed at the farthest point.

Question 7 Deriving U (2 marks)

Starting from $F = -GMm/r^2$, show by integration that the gravitational potential energy is $U = -GMm/r$, taking $U = 0$ at infinity.

Question 8 Kepler's third law (2 marks)

A planet orbits a star at 4.0 times the distance of another planet. Calculate the ratio of their periods.