D.1 Gravitational fields

Checklist

What you should know

After studying this subtopic, you should be able to:

- Explain Kepler's three laws of orbital motion.
- Explain Newton's universal law of gravitation.
- Predict the orbital period.
- Outline conditions under which extended objects can be treated as point objects.
- Explain what is meant by gravitational field and gravitational field lines.
- State the definition of the gravitational field strength g at point in a gravitational field of an object.
- Show that $g = \frac{F}{m}$ and $g = G\frac{M}{r^2}$.

Higher level (HL)

- Explain how the gravitational potential energy E_p of a system is the work done to assemble the system from infinite separation of the components of the system.
- Show that the gravitational potential energy for a two-body system is given by $E_p = -G\frac{Mm}{r}$, where r is the separation between the centre of mass of the two bodies.
- Show that the gravitational potential V_g at a point is the work done per unit mass in bringing a mass from infinity to that point is given by $V_g = -\frac{GM}{r}$.
- Show that the work done in moving a mass m in a gravitational field is given by $W = m\Delta V_g$.
- Define equipotential surfaces for gravitational fields.
- State the relationship between equipotential surfaces and gravitational field lines.
- Show that the gravitational field strength g as the gravitational potential gradient is given by $g = \frac{\Delta V_g}{\Delta r}$.

- Show that the orbital speed v_{orbital} of a body orbiting a large mass as given by $v_{\text{orbital}} = \sqrt{\frac{GM}{r}}$.
- Show that the escape speed v_{escape} at any point in a gravitational field as given by $v_{\text{escape}} = \sqrt{\frac{2GM}{r}}$.
- Discuss the qualitative effect of a small viscous drag due to the atmosphere on the height and speed of an orbiting body.