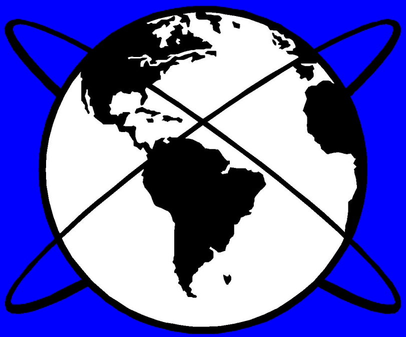
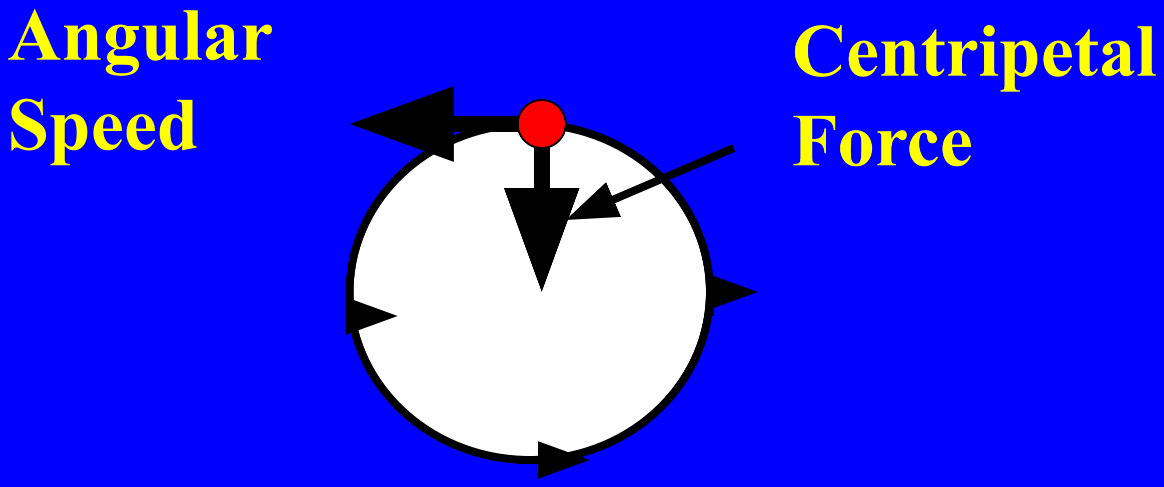
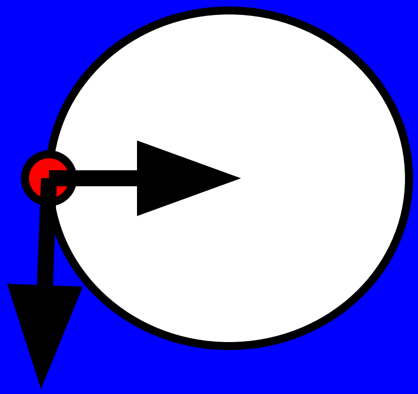
Gravity and Circular Motion Revision
AQA syllabus A
Section 13.3.1-6

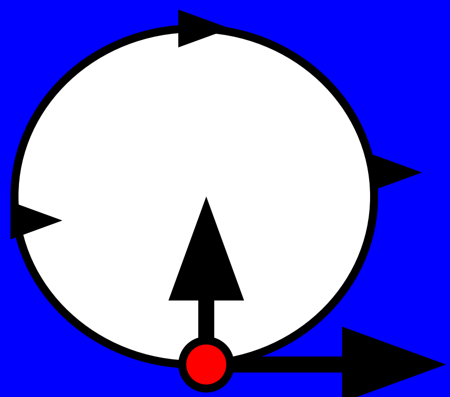


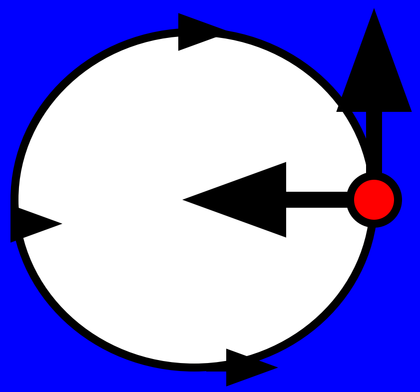
Circular motion

- When an object undergoes circular motion it must experience a
  centripetal force
- This produces an acceleration
  towards the centre of the circle


Angular Speed
Centripetal Force







Angular speed

- Angular speed can be measured in ms^{-1} or
- **$Rads^{-1}$ (radians per second) or**
- **$Revs^{-1}$ (revolutions per second)**
- The symbol for angular speed in radians per second is
- **ω**

Converting to ω

- To convert **v** to **ω**
- **$\omega = v/r$**
- To convert revs per second to **ω**
- **Multiply by 2π**

Acceleration

- The acceleration towards the centre of the circle is
- **$a = v^2/r$ OR**
- **$a = \omega^2 r$**

Centripetal Force Equation

- The general force equation is
- **$F = ma$**
- so the centripetal force equation is
- **$F = mv^2/r$ OR**
- **$F = m\,\omega^2 r$**
- **THESE EQUATIONS MUST BE LEARNED!!**

Example

- Gravity provides the accelerating force to keep objects in contact with a humpback bridge. What is the minimum radius of a bridge that a wheel will stay in contact with the road at 10 ms^{-1}?
- **$v = 10\ ms^{-1}$, $g = 10\ ms^{-2}$, $r = ?$**
- **$a = v^2/r = g$ so $r = v^2/g$**
- **$r = 10^2/10 = 10\ m$**

Newton's Gravitation Equation

- Newton's Gravitation equation is
- **$F = -Gm_1m_2/r^2$**
- **MUST BE LEARNED!!**
- Negative sign is
- **a vector sign**
- G is
- **Universal Gravitational Constant**

More about the equation

- **m_1** and **m_2** are
- **the two gravitating masses**
- **r** is
- **the distance between their centres of gravity**
- The equation is an example of an
- **Inverse square law**

Gravitational field

- A gravitational field is an area of space subject to the force of gravity. Due to the inverse square law relationship, the strength of the field fades quickly with distance.
- The field strength is defined as
- **The force per unit mass OR**
- **$g = F/m$ in Nkg^{-1}**

Radial Field

- Planets and other spherical objects exhibit radial fields, that is the field fades along the radius extending into space from the centre of the planet according to the equation
- **$g = -GM/r^2$**
- Where **M** is
- **the mass of the planet**

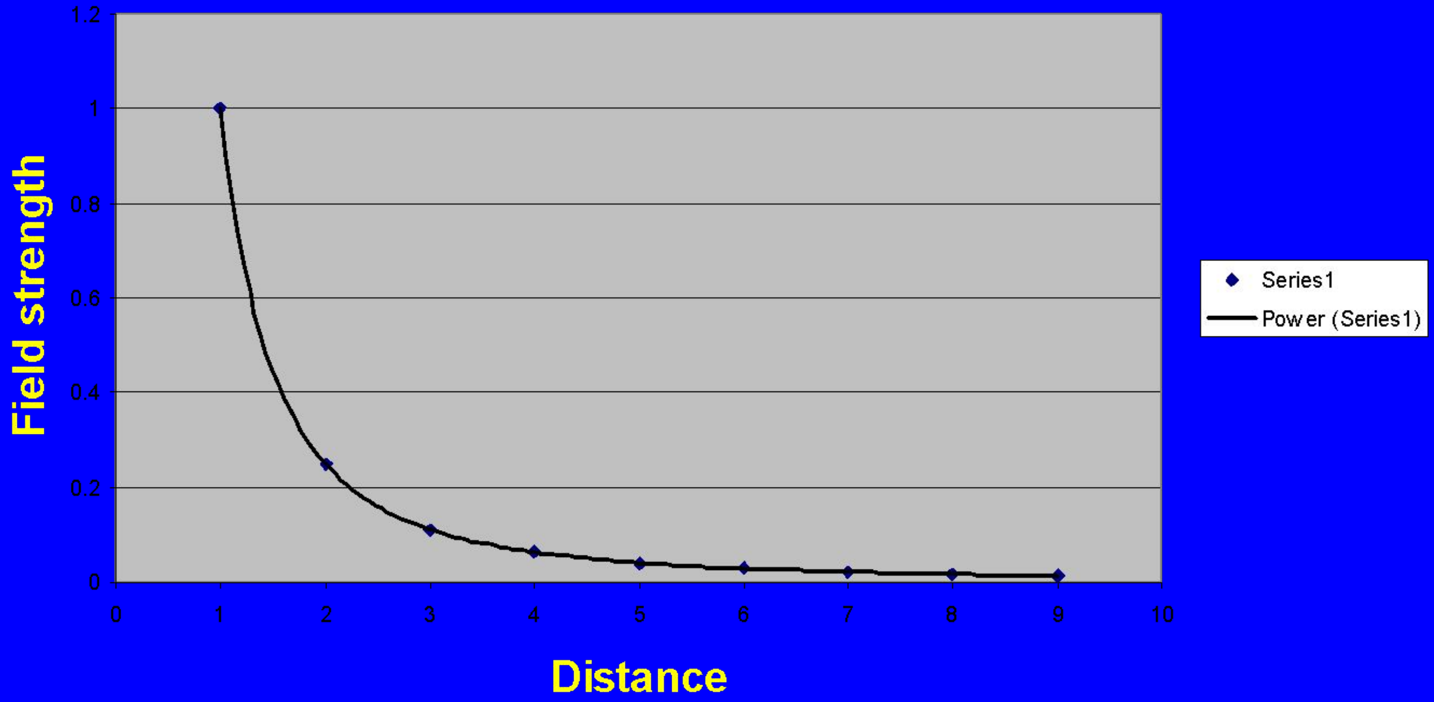
Gravitational Potential

- Potential is a measure of the energy in the field at a point compared to an infinite distance away.
- The zero of potential is defined at
- **Infinity**
- Potential at a point is
- **the work done to move unit mass from infinity to that point. It has a negative value.**
- **The equation for potential in a radial field is**
- **$V = -GM/r$**

Potential Gradient

- In stronger gravitational fields, the potential graph is steeper. The potential gradient is
- **ΔV/Δr**
- And the field strength **g** is
- **equal to the magnitude of the Potential gradient**
- **g = -ΔV/Δr**

Graph of Field strength against distance



Field strength graph notes

- Outside the planet field strength
- **follows an inverse square law**
- Inside the planet field strength
- **fades linearly to zero at the centre of gravity**
- Field strength is always
- **positive**

Graph of Potential against distance

Potential Graph Notes

- Potential is always
- **negative**
- Potential has zero value at
- **infinity**
- Compared to Field strength graph,
- **Potential graph is less steep**

Orbits

- Circular orbits follow the simple rules of gravitation and circular motion. We can put the force equations equal to each other.
- **$F = mv^2/r = -Gm_1m_2/r^2$**
- **So we can calculate v**
- **$v^2 = -Gm_1/r$**

More orbital mechanics

- Period T is the time for a complete orbit, a year. It is given by the formula.
- **$T = 2\pi / \omega$**
- and should be calculated in
- **seconds**

Example

- The Moon orbits the Earth once every 28 days approximately. What is the approximate radius of its orbit? $G = 6.67 \times 10^{-11}\ Nm^2kg^{-2}$, mass of Earth $M = 6.00 \times 10^{24}$ kg
- **$\omega = 2\pi / T = 2\pi/(28x24x60x60) =$**
- **2.6×10^{-6} $rads^{-1}$**
- **$F = m\omega^2 r = -GMm/r^2$ so**
- **$r^3 = -GM/\omega^2$**

Example continued

- $r^3 = 6.67 \times 10^{-11} \times 6.00 \times 10^{24}/(2.6\times10^{-6})^2$
- $= 5.92 \times 10^{25}$
- $r = 3.90 \times 10^8$ m

The End!

- **With these equations we can reach the stars!**