**Dynamics & Space**

**Space Travel**

**Summary**

When an object is projected in a gravitational field (e.g. when a ball is thrown on Earth) it will follow a curved path. This is known as **projectile motion**.

Projectile motion because the only force acting on the object is the force of gravity (weight) acting vertically downwards. This results in a constant downward acceleration. Whereas there are no horizontal forces so the object continues to move with a constant horizontal speed.

The horizontal and vertical motion of a projectile can be treated separately:

 horizontal motion : constant velocity using $s=vt$

 vertical motion : constant downward acceleration using $a=\frac{v-u}{t}$

 (Note: on Earth a = 9·8 ms-2)

A **satellite** is a projectile that remains in orbit because its horizontal velocity sufficiently large that, as it accelerates toward the surface of the Earth, the surface ‘curves away’ from it. Satellites orbit the Earth above the atmosphere (>160 km) so that there is no air resistance to slow them down.

When an object is in freefall it appears to be weightless. For example the astronauts inside a spacecraft appear to be weightless because both the astronauts and the spacecraft are falling towards the Earth at the same rate.

The greater the altitude of a satellite the greater the period of the satellites orbit

|  |  |  |
| --- | --- | --- |
| **Satellite(s)** | **Altitude (km)** | **Period** |
| International Space Station | 420 | 92 minutes |
| Galileo (navigation) | 23 200 | 14 hours |
| Astra (Sky TV) | 35 800 | 24 hours |

e.g.

Satellites that orbit the equator with a period of 24 hours are **geostationary**. Geostationary satellites remain above the same point on the Earth’s surface at all times.

Satellites have many uses including: telecommunications (satellite phones, satellite television etc.), meteorology (weather mapping and prediction), positioning (GPS), environmental monitoring (vegetation, geology, temperature, atmospheric chemicals etc.), imaging (mapping and surveillance) and scientific (experiments and telescopes).

Work done is a measure of the energy transferred during an energy change.

**Work done, Force and Distance**

$$Work done=force ×distance $$

$$E\_{w}=Fd$$

$$F=\frac{E\_{w}}{d}$$

$$d=\frac{E\_{w}}{F}$$

m

J

N

*F*

*Ew*

*d*

Work done is measured in Joules (J).

The work done by a force to an object is equal to the force applied multiplied by the distance travelled.

Note : When an object is lifted the force applied to lift the object at constant speed is equal to its weight (*W=mg*) and the distance it travels is equal to the height, *h*. Therefore the work done in lifting the object is equal to *mg* multiplied by *h*. This means the gain in gravitational potential energy is equal to *mgh* (*Ep = mgh*).

When an object enters the Earth’s atmosphere it experiences friction with the atmosphere. The work done by friction changes kinetic energy into heat. To protect spacecraft returning from space heat shielding is required. There are two main types of heat shielding:

 dissipation – Some heat shields (e.g. on the Space Shuttle) absorb the heat using insulating tiles which then re-radiate the heat back into the atmosphere. These tiles have a high specific heat capacity and a high melting point.

 ablation – Some heat shields (e.g. those on Apollo and Soyuz spacecraft) use the heat to vaporise the heat shield and carry away the energy. The materials used in these heat shields have a high specific latent heat.

The heat energy required to change the state of one kilogram of a substance is known as its **specific latent heat**.

**Specific Latent Heat**

$$Heat energy=\begin{matrix}specific\\latent\\heat\end{matrix} ×mass $$

$$E\_{h}=lm$$

$$l=\frac{E\_{h}}{m}$$

$$m=\frac{E\_{h}}{l}$$

kg

J

Jkg-1

*l*

*Eh*

*m*

Specific latent heat is measured in joules per kilogram (Jkg-1).

When a substance change state from a solid to a liquid or a liquid to a gas latent heat is absorbed (taken in).

When a substance changes state from a gas to a liquid or a liquid to a solid latent heat is released (given out).

**Specific latent heat of fusion** is the amount of heat energy required to change one kilogram of a substance from a solid at its melting point to a liquid at the same temperature

**Specific latent heat of vaporisation** is the amount of heat energy required to change one kilogram of a substance from a liquid at its boiling point to a gas at the same temperature.

During a change of state there is no change in temperature.