SIMPLE HARMONIC MOTION

DEFINITION

- An object moving with simple harmonic motion oscillates up and down or side to side.
- Displacement (x) is the distance of the object from the midpoint.
- The **RESTORING FORCE** acts in the opposite direction to displacement, towards the midpoint.
- The bigger the displacement, the bigger the restoring force, and it causes the object to accelerate towards the midpoint.
- So the definition of SHM is: **WHEN ACCELERATION IS DIRECTLY PROPORTIONAL TO THE DISPLACEMENT ABOUT THE MIDPOINT AND IS DIRECTED TOWARDS THE MIDPOINT.**
- $a = -(2\pi f)^2 x$

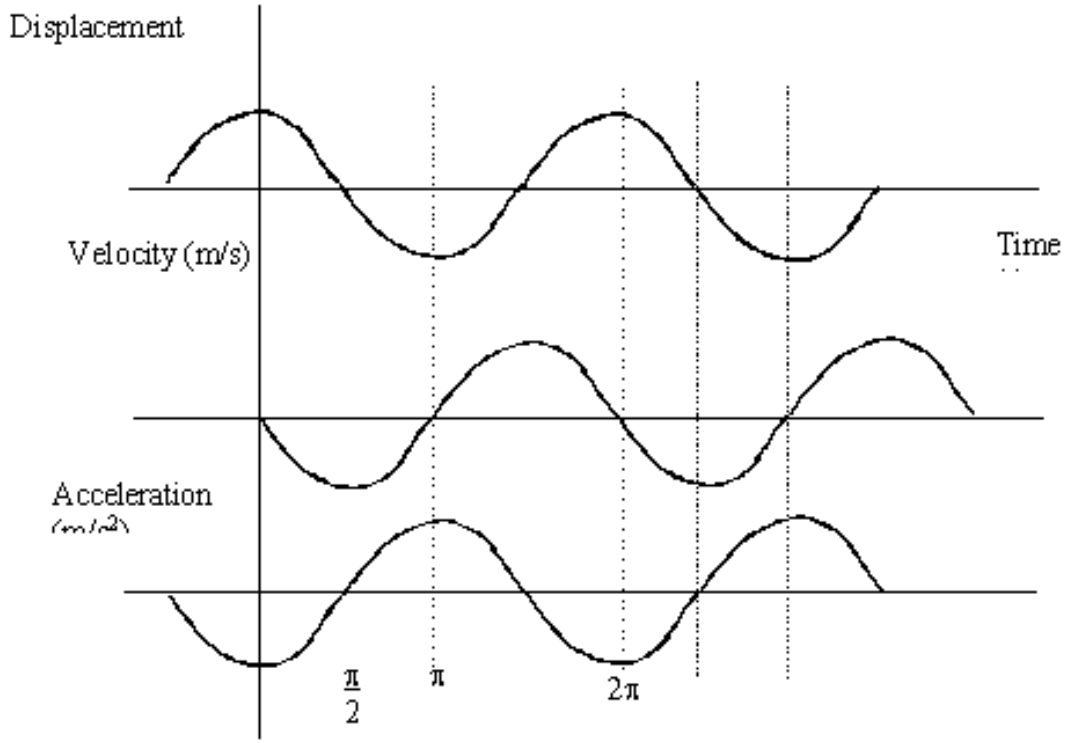
ENERGY TRANSFER

- As the object oscillates it will exchange kinetic energy and potential energy.
- At the midpoint, kinetic energy will be highest and potential energy lowest.
- At maximum displacement (the **AMPLITUDE**) potential energy will be highest and kinetic energy lowest.
- The total amount of energy remains the same provided no external forces act (eg: friction).
- A **FREE OSCILLATION** is one that never stops. It has no driving force and is not affected by friction – this never actually happens.
- The **RESTORING FORCE** transfers energy between kinetic & potential

EQUATIONS

- If the time starts when the object is at its midpoint (i.e.: displacement = 0) then $\boldsymbol{x = ASin(2\pi ft)}$, as a **SINE GRAPH** of distance against time is used.
- If the time starts when the object is at either side of the midpoint (i.e.: maximum displacement) then $\boldsymbol{x = ACos(2\pi ft)}$, as a **COSINE GRAPH** of x against t is used.
- An objects velocity is maximum when it is at the midpoint, therefore $\boldsymbol{v_{max} = 2\pi fA}$, as this works for a sine or cosine graph of v against t.

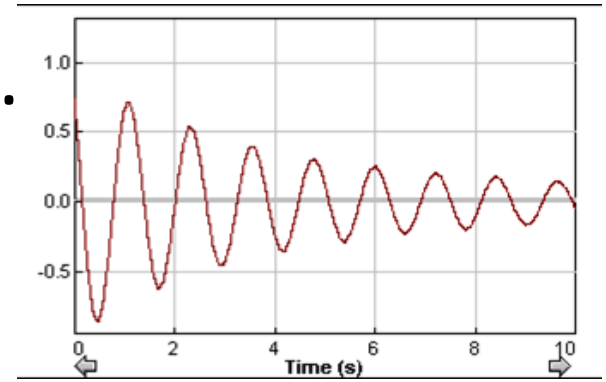
GRAPHS



- The velocity/time graph is: the **gradient** of the displacement graph
- And the displacement graph translated to the left by **π/2**
- The acceleration/time graph is: the **gradient** of the velocity graph
- The velocity graph translated to the left by **π/2**
- And the displacement graph reflected in the **x axis**.

DAMPING

- Damping is the **REDUCTION IN AMPLITUDE** of an oscillation over time, usually due to energy loses to the surroundings (e.g. from friction).
- The reduction in amplitude is **EXPONENTIAL**.
- **CRITICAL DAMPING** is when the amplitude is reduced to zero straight away.
- The graph shows **light damping**.



RESONANCE

- Occurs when the frequency of the driving force **EQUALS THE NATURAL FREQUENCY** of the oscillation.
- It causes the **AMPLITUDE OF THE OSCILLATION TO BE MAXIMUM**, as the driving force can transfer the most energy to the object.
- Shock absorbers act as dampers and reduce the maximum amplitude.