Vertical Circles *There are three main types of vertical circular motion, and each one must be treated differently.*

Type of Motion	Centripetal Force	High speeds	Lower speeds	Very low speeds	How to solve
Inner Circles Eg: • weight on a string • car doing a loop-the-loop 	Provided by: **Tension** in the string or **Normal reaction** of the track (acting radially) ***combined with*** the **radial component of weight**.	The object describes **complete circles.**	The object travels partway round the circle then **falls inwards** at the moment where **tension** or **normal reaction** drops to **zero**.	If the object doesn't have enough energy to go beyond the halfway point it simply **oscillates** abound the **lowest point** of the circle.	**Energy:** to find the speed at a particular point. **Forces:** resolving radially and applying $\boldsymbol{F = ma}$ to find tension or normal reaction at a specific point. **This cannot be negative if the string is taut (or the object is in contact with the surface),** so if it reaches 0, the object is on the point of falling inwards.
Outer Circles Eg: • object balanced on a sphere • car driving over a bridge 	Provided by: **Normal reaction** (acting *away from* the centre), ***combined with*** the **radial component of weight**.	Once the normal reaction becomes zero, the object **falls outwards** from the circular path.	While there is still a normal reaction force acting away from the centre, the object will continue to travel in **circular motion**.	While there is still a normal reaction force acting away from the centre, the object will continue to travel in **circular motion**.	**Energy:** to find the speed at a particular point. **Forces:** resolving radially and applying $\boldsymbol{F = ma}$ to find the normal reaction at a specific point. **This cannot be negative if the object is still in contact with the surface,** so the instant it reaches 0, the object is on the point of falling outwards.
Fixed Circles Eg: • roller-coaster car on a track • bead threaded on a wire 	Provided by: **Normal reaction** (acting either *towards* or *away from* the centre), ***combined with*** the **radial component of weight.**	The object describes **complete circles** and the normal reaction acts **towards the centre**.	The object may still describe **complete circles**, but the normal reaction will be acting **away from the centre** for the part of the motion when the speed is very low.	The object **oscillates** about the lowest point if the **speed** drops to 0 before reaching the top. Normal reaction may point **towards or away from the centre**.	**Energy:** to find the speed at a particular point. **Forces:** resolving radially and applying $\boldsymbol{F = ma}$ to find the normal reaction at a specific point. **May be positive or negative**, as the normal reaction may point in or outwards. Since the object cannot leave the circular path, the key factor is the **speed of motion** at each point.