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VCE Physics Unit 3

Area Of Study 1, Motion In One And Two Dimensions, Study Notes 6

Conical Pendula

A conical pendulum is a mass hung from a piece of string and swung around in a horizontal circle.

The mass travels in circular motion on a horizontal plane, but the centripetal force (horizontal, towards the centre of the circle) giving the acceleration for the circular motion is the resultant of the vector addition of the weight force of the mass and the tension force in the string.

Weight force and centripetal force are perpendicular to each other. Vector addition and trigonometry must be used to find unknown values.

$$\vec{F}_C = \vec{F}_W + \vec{F}_T$$

$$\rightarrow \frac{mv^2}{r} = mg + \vec{F}_T$$

Where F_C = Force (centripetal, on horizontal plane), in N
F_W = Force (weight, vertically downwards), in N
F_T = Force (tension, in string, upwards at some angle), in N
m = Mass, in kg
v = magnitude of velocity (speed), in ms^{-1}
r = radius (of circle), in m
g = acceleration due to gravity, as 9.8 or 10 ms^{-2}

Banked Circuits

Cycling velodromes and “oval track” racing car circuits (also known as “speedways”), have circular sections to their paths. The road surface of such racing tracks is inclined (angled downwards) towards the centre of the circular sections. These are known as “banked” circuits.

By “banking” a road surface downwards towards the centre of its circular path, a component of a vehicle’s weight force is directed towards the centre of the horizontal circle around which it travels. This contributes to the centripetal force required to accelerate a vehicle in the direction of a circular path, meaning that less friction is required between the road surface and the vehicle’s tyres. At a speed corresponding to the angle of the road’s incline, a vehicle can steer as though it’s moving straight, but still be accelerated in the direction of the circular road’s path.

A vehicle on a banked circuit travels in circular motion on a horizontal plane, but the centripetal force (horizontal, towards the centre of the circle) giving the acceleration for the circular motion is the resultant of the vector addition of the weight force of the vehicle and the “normal” (reaction) force upwards perpendicular to the road.

Weight force and centripetal force are perpendicular to each other. Vector addition and trigonometry must be used to find unknown values.

$$\vec{F}_C = \vec{F}_W + \vec{F}_N$$

$$\rightarrow \frac{mv^2}{r} = mg + \vec{F}_N$$

Where F_C = Force (centripetal, on horizontal plane), in N
F_W = Force (weight, vertically downwards), in N
F_N = Force (normal, upwards perpendicular to surface), in N
m = Mass, in kg
v = magnitude of velocity (speed), in ms^{-1}
r = radius (of circle), in m
g = acceleration due to gravity, as 9.8 or 10 ms^{-2}