Conical Pendulum 18.2

A Level

A small sphere of mass $2.0\,\mathrm{kg}$, attached to the end of a light string of length $90\,\mathrm{cm}$ at 24° to the vertical, moves in a horizontal circle.

Part A Tension

Calculate the tension T in the string.

Part B Height above position at rest

Calculate the height h by which the mass is raised above its position at rest.

Conical Pendulum 18.3

A Level

A lead ball of mass $45\,\mathrm{g}$ is attached to the end of an $80\,\mathrm{cm}$ long light string and swung around in a horizontal circle at high speed.

If the string snaps at a tension of $195\,\mathrm{N}$, what is the maximum frequency of rotation f possible?

Conical Pendulum 18.7

A Level

An aircraft travelling at $160\,\mathrm{knots}$ maintains its altitude during a circular banked "rate one turn", which is a $3.0^\circ\,\mathrm{s}^{-1}$ turning rate. $(1\,\mathrm{knot} = 0.514\,\mathrm{m\,s}^{-1})$

At what angle to the horizontal are the wings of the plane?

Vertical Circles 19.1

A Level

An object travels in a vertical circle. Using the equations in the notes page, and writing upwards normal reactions as positive, write an equation for

Part A N (bottom) using W, m, a

N for the mass at the bottom using W, m and a.

The following symbols may be useful: `N, W, a, m`

Part B N (bottom) using m, r, g, u

N for the mass at the bottom using m, r, g and u.

The following symbols may be useful: `N, g, m, r, u`

Part C N (top) using W, m, a

N for the mass at the top using W, m and a.

The following symbols may be useful: `N, W, a, m`

Part D N (top) using m, r, g, v

N for the mass at the top using m, r, g and v.

The following symbols may be useful: `N, g, m, r, v`

Part E N **(top) using** m, r, g, u

N for the mass at the top using m, r, g and u.

The following symbols may be useful: `N, g, m, r, u`

Part F v **if** $N = 0$

the speed v needed at the top if $N = 0$.

The following symbols may be useful: `N, g, m, r, v`

Part G u if $N = 0$ at top

the speed u needed at the bottom if $N = 0$ at the top.

The following symbols may be useful: `N, g, m, r, u`

Vertical Circles 19.2

A Level

Calculate the normal reaction for the car in the Example in the notes page at a speed of $8.0\,\mathrm{m\,s^{-1}}$.

Vertical Circles 19.3

A Level

For the car in the Example in the notes page, calculate the speed at which the wheels would just leave the ground at the top of the bridge.

Vertical Circles 19.6

A Level

A person feels weightless when $N = 0$.

Calculate the speed a roller-coaster car would have to be travelling at the top of an $r = 4.5\,\mathrm{m}$ loop in order for the riders to experience weightlessness at the top.

Vertical Circles 19.7

A Level

An $850\,\mathrm{g}$ radio-controlled car is driven in circles around the inside of a large (empty) pipe with a radius of $90\,\mathrm{cm}$. It travels at a steady $4.0\,\mathrm{m\,s^{-1}}$.

Part A Fast enough not to fall off?

Is the car going quickly enough not to fall off the pipe's surface?

- Yes, more than quickly enough
- No
- Yes, but only just

Part B Normal reaction at top

Calculate the normal reaction as the car passes the top.

Part C Normal reaction at bottom

Calculate the normal reaction as the car passes the bottom.

Vertical Circles 19.8

A Level

When roller-coaster riders describe their rides, they call the ratio N/mg the *g-force* (this is not a scientific term). In this formula, N is taken as positive if it is directed upwards through the rider's body towards their head. A roller-coaster is designed to give $N/mg = 2.5$ at both the top and the bottom of the ride. The loop is not circular. The rider sits in a train which runs around the inside of the loop. The top of the loop is curved with a $7.6\,\mathrm{m}$ radius.

Part A Rider at rest

State the value of N/mg for a rider sitting at rest in the train.

Part B Speed at top

Calculate the speed of the train at the top of the loop.

Part C Speed at bottom

If there is no friction, and the top of the loop is $21\,\mathrm{m}$ above the bottom, how fast will the train travel at the bottom of the loop?

Part D Radius at bottom

Calculate the radius of the loop at the bottom of the track.