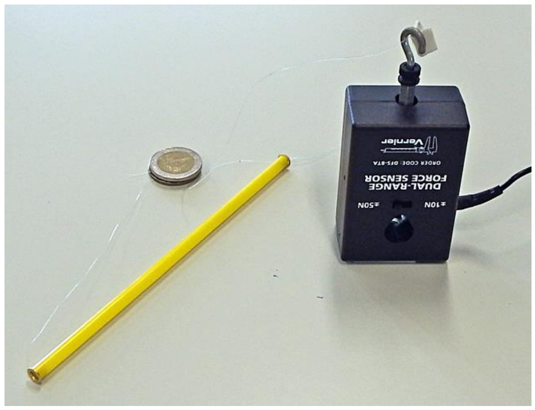
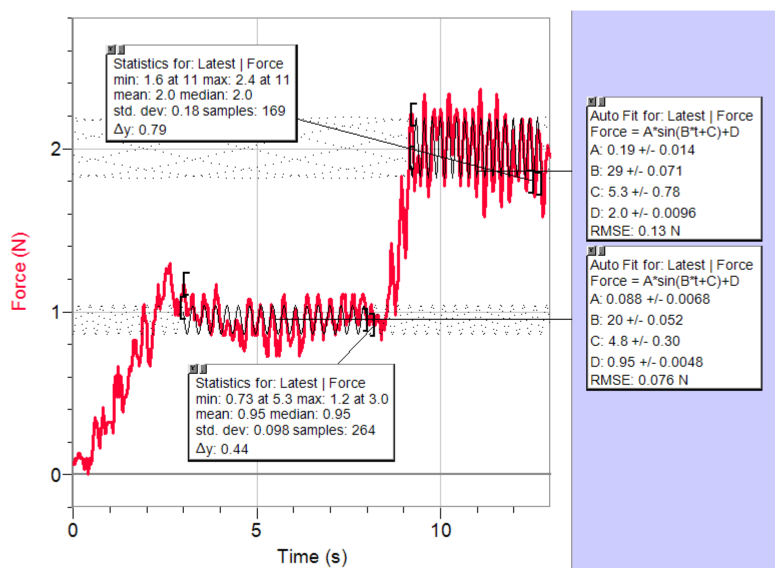
Centripetal force

A semi-quantitative demonstration

A mass of 17.5 g is attached to nylon line with double sided tape. The line is threaded through a plastic tube and attached to a force probe. A rivet is inserted in the tube to reduce friction.



Holding the tube vertically at a measured distance above the probe (to keep the radius of the circular motion constant) and rotating the mass at different high speeds plots a tension versus time graph modulated by the frequency of rotation.



Notice that as the frequency of rotation increases the centripetal force increases.

Both the centripetal force T and the angular frequency ω can be found from the graph. The mass of the coins is measured as 17.5 g and the radius of the circular motion (in this case 15 cm) can be found to the nearest cm.

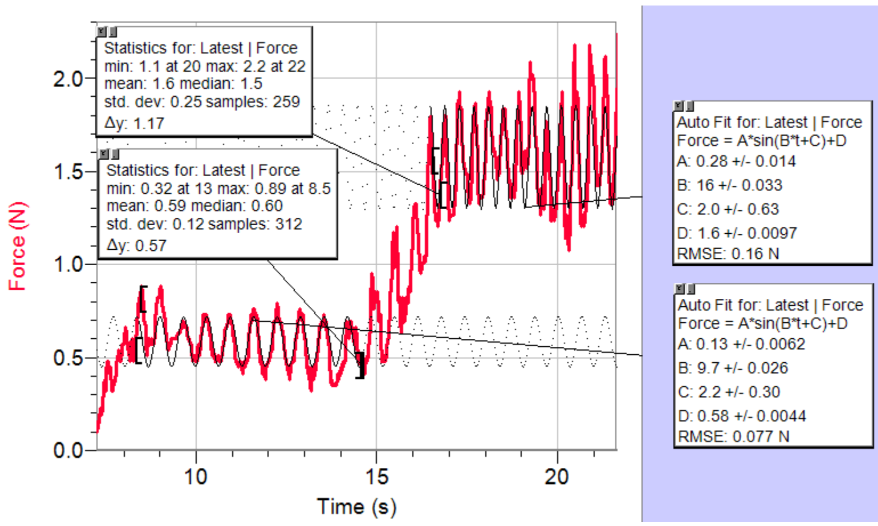
Centripetal force values calculated as $ml\omega^2$ are compared with the measured values of tension. Because there is significant friction as the nylon passes over the rivet the calculated values are expected to be close to, but not exactly the same, as the measured values of tension.

$$ml\omega_1^2 = 0.0175\text{x}0.15\text{x}20^2 = 1.0 \text{ N}$$

$$ml\omega_2^2 = 0.0175\text{x}0.15\text{x}29^2 = 2.2 \text{ N}$$

The calculated values are the same as the average measured tensions 0.95 and 2.0 N within errors.

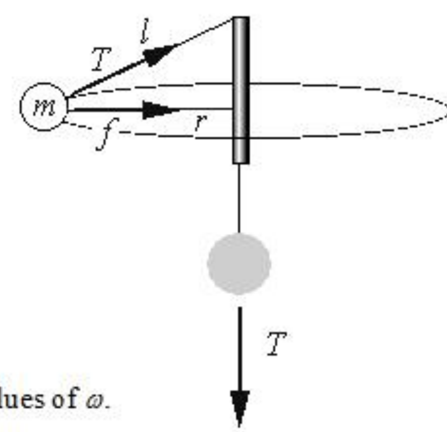
A second example is shown below.



The radius was 40 cm. The calculated forces are 0.66 and 1.8 N, close to the average measured values of tension, 0.6 and 1.6 N.

Note: using $T = ml\omega^2$ assumes that the mass swings in a horizontal circle: ie. $T = f$ and $r = l$, which is not strictly true. The motion is that of a conical pendulum (see the diagram below).

On the diagram we see that $T/f = l/r$



Substituting for T in the expression above $(l/r)f = ml\omega^2$

and ….. $f = mr\omega^2$

$T = ml\omega^2$ is equivalent to the expression $f = mr\omega^2$ for all values of ω.