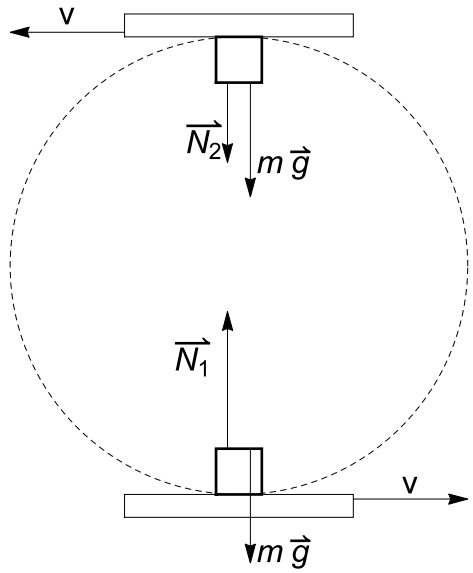
Centripetal motion and rotation

Constant $\omega$.

1. During an air show a plane flying at speed $v = 250\,m/s$ performs a loop-of-death a vertical circle with a radius $R = 1800\,m$ (see figure - not to scale). The pilot has a mass $M = 80\,kg$. Find the magnitude of the normal force $N_1$ (apparent weight) acting on the pilot (a) at the lowest and (b) at the highest points of the loop.




2. A small ball with mass $M = 2\,kg$ is fixed to a massless rod and is revolving in a circle of radius $r = 0.5\,m$ with linear speed of $v = 3\,m/s$.

   (a) find the period of revolution $T$

   (b) the angular velocity $\omega$

   (c) centripetal acceleration $a_c$

   (d) centripetal force $F_c$

   (e) moment of inertia $I$ about the axis of rotation

   (f) kinetic energy $K$

3. A Ferris Wheel has a radius $R = 25\,m$ and completes one full revolution in $1\,min$.

   (a) Draw clear force diagrams at the highest and the lowest points

   (b) find the apparent weight of an $M = 40\,kg$ child at those points.

   (c) for which rotational speed (in $rev/s$) the child would feel weightless at the top. What would be his acceleration?

   (d) for the above acceleration, what is the apparent weight (in units of $Mg$) at the lowest point?

4. A car goes around a flat curve with $R_1 = 100\,m$ at a speed $v_1 = 30\,m/s$, and then around another curve with $R_2 = 200\,m$ and $v_2 = 60\,m/s$.

   (a) Find the ratio the ratio of centripetal forces $F_1/F_2$

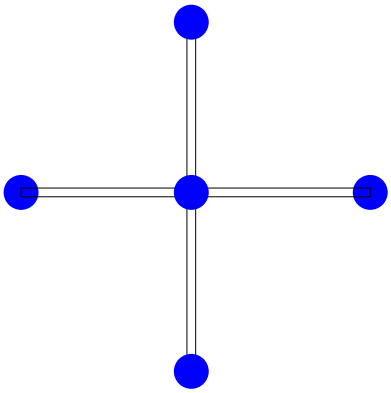
   (b) find the minimal value of the friction coefficient, which would ensure that the car safely makes each of the curves.

$\omega \neq$ const.

5. A wheel makes 1000 revolutions in 10 s and stops. (a) Find $\omega_0$ ; (b) find $\alpha$.

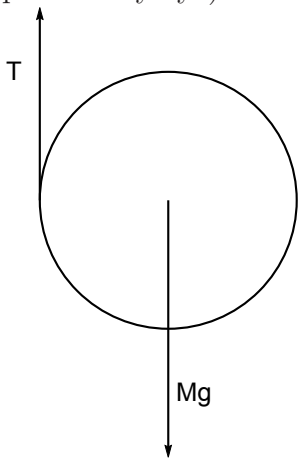
$I$ and $K$

6. Calculate rotational inertia and energies of rotation (note the difference between $rad/s$ and $rpm$). All spheres are solid with mass $M = 5\,kg$ each and of negligible radius. Each of the two rods is $L = 2\,m$ long with negligible mass.
(a) the axis of rotation is perpendicular to the figure and passes through the middle sphere; rotation at $1000\,rpm$.
(b) The axis of rotation is vertical in the plane of the page and passes through 3 spheres; $\omega = 10\,rad/s$.



7. A solid disk with $M = 2\,kg$ and $R = 10\,cm$ is rolling with $v = 3\,m/s$. Find full $K$.

8. A solid disk with $r = 1\,m$ and $M = 1\,kg$ falls from unwinding string (as in a primitive yo-yo).




   (a) use conservation of energy to find linear speed $v$ once the disk lowers by $h = 50\,cm$.

   (b) from $h = v^2/2a$ find the linear acceleration $a$

   (c) find $\alpha$, the angular acceleration

9. A disk, a hoop and a solid sphere ($I = \frac{2}{5}MR^2$) roll down a $6\,m$ long incline which makes $30^o$ with horizontal. Find the speed of each at the bottom of the incline. Make your own assumptions about masses and radii.

   (a) disk

   (b) hoop

   (c) sphere

   (d) which one wins?