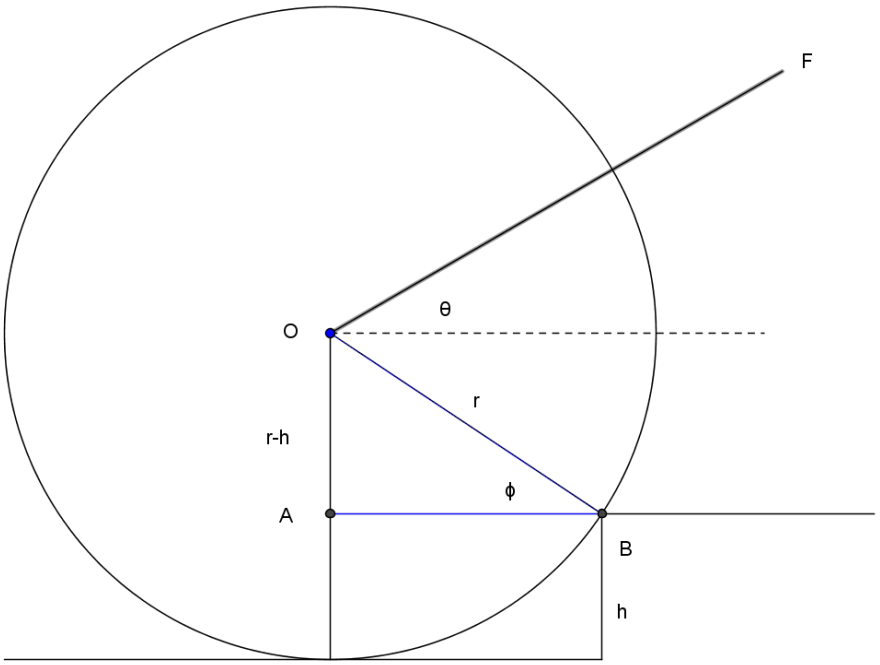
Force required to lift a wheel over a step

Dr Richard Kenderdine

Consider a wheel of radius r m and mass M kg that has to be dragged over a step of height h m. We need to calculate the force F required at angle θ and the reaction at the step corner B.



First we need to calculate the distance $AB = \sqrt{r^2 - (r-h)^2} = \sqrt{h(2r-h)}$

The vertical component of F is $F\sin\theta$ and the horizontal component is $F\cos\theta$.

Taking clockwise moments about B we have

$$F\cos\theta\,(r - h) + F\sin\theta\,\sqrt{h(2r-h)} - Mg\sqrt{h(2r-h)} = 0$$

So
$$F = \frac{Mg\sqrt{h(2r-h)}}{\cos\theta\,(r-h) + \sin\theta\,\sqrt{h(2r-h)}}$$

The reaction at B can be found by calculating the component of the vertical forces along the vector BO.

The net vertical force is $F\sin\theta - Mg$ and the component along BO is $\frac{F\sin\theta - Mg}{\sin\phi} = \frac{r(F\sin\theta - Mg)}{r-h}$