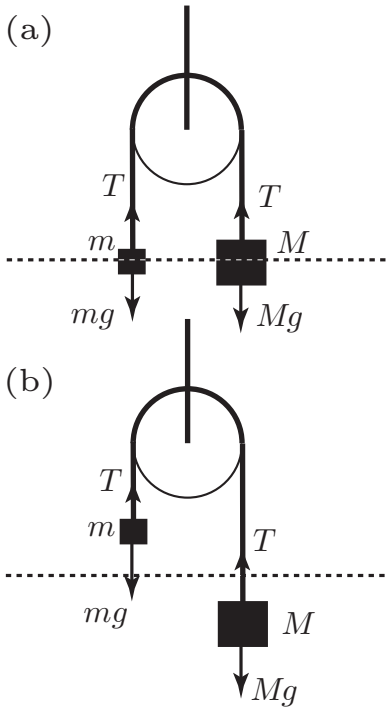
10. Motion of connected particles

Two masses m and M, with $M \geq m$, are connected by a light, inextensible string which passes over a pulley. When the pulley is smooth the tension, T, in the string is the same throughout its length. Because the string is inextensible the accelerations of the two masses have the same magnitude a. In motion both masses will have the same speed and travel the same distances. The system is released from rest in the position shown in (a).



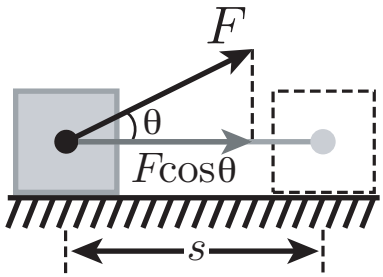
When in motion, (b), from Newton's 2nd law: $T - mg = ma$, and $Mg - T = Ma$, from which

$$a = \left(\frac{M-m}{M+m}\right) g, \qquad T = \frac{2Mmg}{M+m}$$

11. Work, Energy and Power

Work done by a constant force: The figure below represents a body moving in a horizontal direction. A constant force, $\underline{F}$, at an angle θ to the direction of motion, is exerted on the body. The **work done**, W, by the force, when its point of application undergoes a displacement $\underline{s}$, is $W = \underline{F} \cdot \underline{s} = (F\cos\theta)s$. Work is a scalar quantity.

If the component of the force is in the same / opposite direction as the displacement, the work done is positive / negative respectively. If the force is at right angles to the displacement the work done is zero.



Energy: When a force does work on a body the body can gain or lose energy.

Kinetic Energy: K.E. is due to a body's motion. When a body of mass m moves with speed v its K.E. is defined as K.E. $= \frac{1}{2}mv^2$. The change in the K.E. of a rigid body is equal to the work done by the external forces on the body.

Potential Energy: P.E. is due to a body's position.

Gravitational Potential Energy is the product of the weight, mg, of a body and the height, h, of its centre of gravity above a reference level. So P.E. (gravitational) $= mgh$.

Conservation of Total Mechanical Energy: When the only force acting on the body is the gravitational force, the total mechanical energy, which is the sum of the kinetic and potential energies of the body, is conserved.

Power and Velocity: The rate at which work is done is called the **power**. If a constant force $\underline{F}$ is exerted on a body which moves with speed v in the direction of the force, then the power is $P = Fv$.