Dynamics

Motion of Two Connected Particles

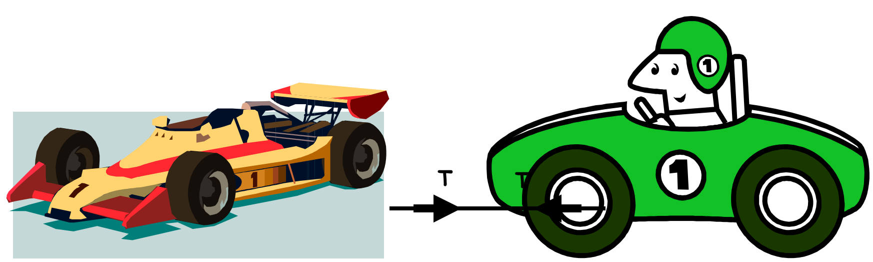
Newton's Third Law

Before we can consider the motion of two connected particles we need to discuss **Newton's Third Law**. This law states that action and reaction are equal and opposite.

If two bodies A and B are in contact and exert forces on each other, then the force exerted by A on B is equal in magnitude and opposite in direction to the force exerted by B on A.

This principle will be applied to tow truck problems and pulleys to name but two.

Consider the situation below where the cartoon car is towing a racing car.



The racing car is pulled forward by tension in the tow bar. The racing car will exert an equal but opposite force on the car. If the car is slowing down and there are no breaks on the racing car then some force must be acting in the opposite direction to the direction of motion of the two cars. In this case the tow bar will exert a thrust on both cars (arrows change directions).

<u>Example 7</u>

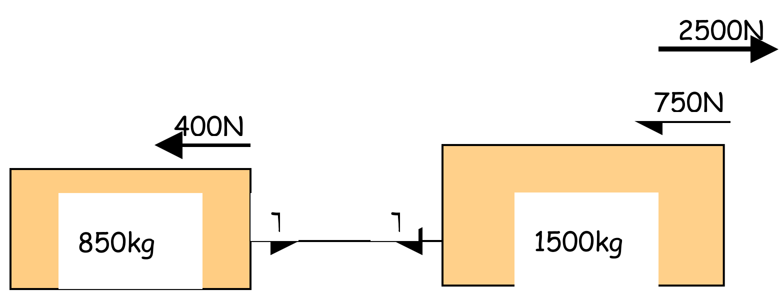
The AA man is towing a car along a straight horizontal road. The truck has a mass of 1500kg and the car has a mass of 850kg. The truck is connected to the car by a bar which is to be modelled as a light inextensible string. The truck's engine produces a constant driving force of 2500N. The resistance to motion of the truck and the car are constant and of magnitude 750N and 400N respectively. Find:

a) the acceleration of the truck and the car;

b) the tension in the rope.

When the truck and the car are traveling at 22ms^{-1} the tow bar breaks. If the magnitude of the resistance to motion of the truck remains at 750N calculate:

c) the time difference in achieving a speed of 30ms^{-1} with and without the car in tow.



a) Setting up equations of motion for the car and truck separately gives:

Car $T - 400 = 850a$ Truck $2500 - 750 - T = 1500a$

Adding the two equations gives:

$$1350 = 2350a$$

$$a = 0.574\text{ms}^{-2}$$

b) Finding the tension:

Substituting the value into the car's equation of motion gives:

$$T - 400 = 850 \times 0.574$$

$$T = 888\text{N}$$

c) If we assume that the bar doesn't break then the time required to reach 30ms^{-1} is calculated by using the constant acceleration equations.

$u = 22$, $v = 30$, $a = 0.574$, $t = ?$

$$v = u + at$$

$$30 = 22 + 0.574t$$

$$t = 13.9 \text{ sec}$$

At the point that the tow bar breaks, the tension in the bar is no longer acting against the truck. Therefore the equation of motion of the truck becomes:

$$2500 - 750 = 1500a$$

$$a = 1.167 ms^{-2}$$

$u = 22$, $v = 30$, $a = 1.167$, $t = ?$

$$v = u + at$$

$$30 = 22 + 1.167t$$

$$t = 6.9 \text{ sec}$$

Therefore there is a time difference of 7 seconds.