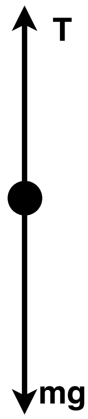
Worked examples: Power

The loaded cab of an elevator has a mass of 3.0×10^3 kg and moves 210m up the shaft in 23s at constant speed.

At what average rate does the force from the cable do work on the cab?



Solution: Since the elevator is moving at constant speed, there is no net force, so

$T = mg$
$= 3000 \times 9.8 = 29.4$ kN

The work done by the tension force over the distance is

$W = Td = 29.4 \times 10^3 \times 210$
$= 6.17 \times 10^6$ J

Hence the rate of doing work (the power) is

$P = W/\Delta t = 6.17 \times 10^6$ J / 23 s
$= 2.7 \times 10^5$ W
$= 270$ kW

Alternately: the speed of the elevator is

$v = \Delta x / \Delta t = 210$ m / 23 s $= 9.13$ ms^{-1}

so the power P is

$P = Fv = 29.4 \times 10^3$ N $\times$ 9.13 ms^{-1}
$= 2.7 \times 10^5$ W

Overtaking a truck

(Example 10.17)

Your 1500 kg car is behind a truck travelling at 90 km h^{-1} (= 25 m s^{-1}). To pass it, you speed up to 120 km h^{-1} (33 m s^{-1}) in 6.0 s.

What engine power is required to do this?

Solution: The initial kinetic energy of your car is

$K_i = ½mv_i^2 = 0.5 \times 1500 \times (25)^2 = 4.79 \times 10^5$ J

The final KE, after you speed up, is

$K_f = ½mv_f^2 = 0.5 \times 1500 \times (33)^2 = 8.17 \times 10^5$ J

So the work done by the engine is

$W = \Delta K = 8.17 \times 10^5 - 4.79 \times 10^5$ J $= 3.5 \times 10^5$ J

To transform this amount of energy in 6.0 s, the power required is

$P = W / \Delta t = 3.5 \times 10^5$ J / 6 s = 58×10^3 W = 58 kW

A typical car has an engine power of ~ 90 kW, but a small car might have only a ~50 kW engine. Given that at that speed you need 10–15 kW of engine power just to maintain a constant speed (to overcome air + road resistance), the small car will not have enough power to overtake the truck in that time.