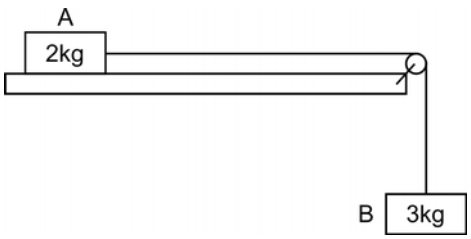
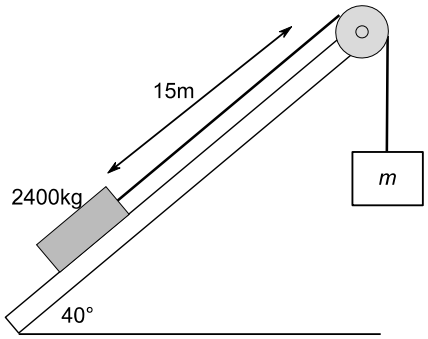
Friction & Air Resistance – Tutorial

1. Mass A (2kg) and mass B (3kg) are joined by a light inextensible string which passes over a smooth pulley fixed at the edge of a smooth horizontal table.
Initially, A is held at rest on the table while B hangs freely over the side of the table.
The coefficient of friction between the table and mass A = 0.5.



By applying Newton's second law to A and to B, calculate:
   (a) the acceleration which occurs when the system is released. *(3.92 m/s^2)*
   (b) the tension in the string. *(17.6 N)*

2. A stone block of mass 2400 kg is to be pulled up an inclined plane of at 40° to the horizontal by a steel cable over a pulley as shown.
coefficient of friction between stone and plane = 0.59.



Calculate:

   (a) the mass m_a required to prevent the block from sliding down the plane. *(458 kg)*

   (b) the larger mass m_b required to pull the stone 15 m up the plane in 10 s. *(2700 kg)*

3. A 68 kg skydiver jumps out of an aeroplane.
density of air = 1.2 kg/m^3
area of skydiver = 0.7 m^2 (before opening chute) = 30 m^2 (chute open)
drag coefficient = 0.45 (before opening chute) = 1.5 (chute open)

   (a) Before the parachute is opened, calculate the skydiver's
      (i) acceleration when falling at 20 m/s *(8.7 m/s^2)*
      (ii) acceleration when falling at 40 m/s *(5.4 m/s^2)*
      (iii) terminal velocity *(59.4 m/s)*

   (b) The parachute is opened when falling at terminal velocity. Calculate the acceleration when the parachute is opened at this speed. *(1390 m/s^2)*

4. A table tennis ball is released from the bottom of a swimming pool, and rises to the surface under the influence of a buoyancy force which, according to Archimedes' principle, is equal to the weight of displaced water.
ball radius = 20 mm, ball mass = 2.7 g; density of water = 1000 kg/m^3
drag coefficient = 0.5
Calculate the terminal velocity reached. (0.96 m/s)