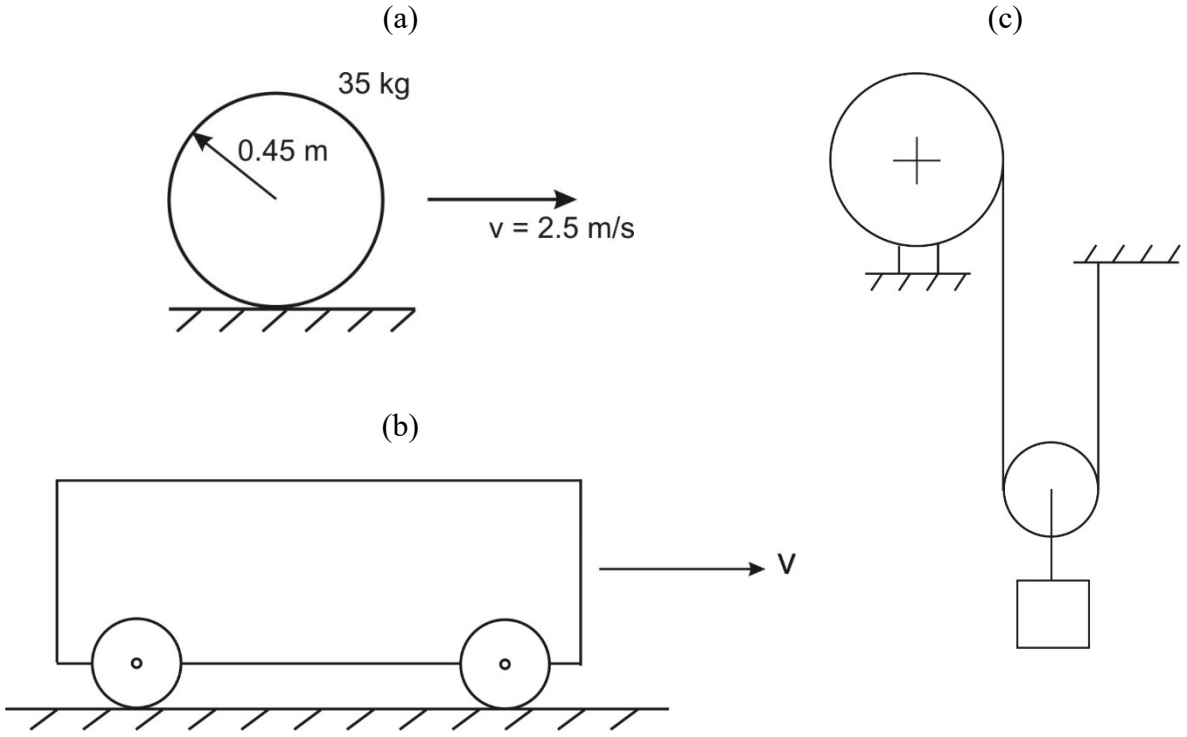
Dynamics 2 – Tutorial 8

Kinetic Energy and the Power Method for Systems

1. (a) The uniform steel disc, shown below, is rolling along a table at 2.5 m/s. Calculate its kinetic energy. [164 Nm]
   (b) A four wheeled trailer is shown. The total mass is 400 kg. Treat each wheel as a uniform disc of 35 kg mass and 700 mm diameter. What is the trailer's kinetic energy when it is travelling at some general velocity? Write it as: (numerical value) × v^2. [$235v^2$]
   (c) The figure shows a 250 kg mass attached by a wire through a (massless) pulley to a drum (radius 0.8 m). The drum has a moment of inertia of 45kgm^2. What is the system kinetic energy when the descending mass is at a velocity V? [$(265.6)V^2$]

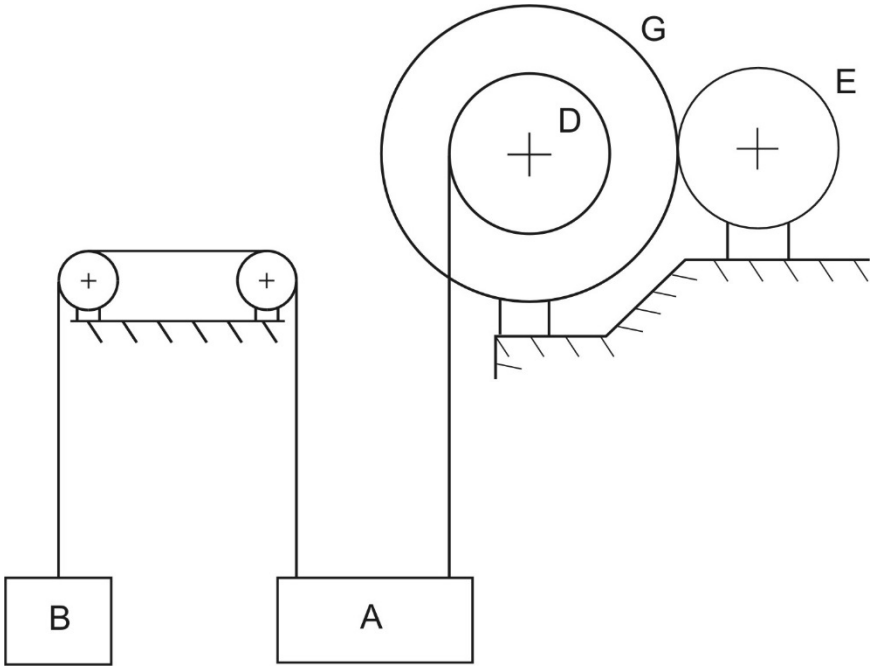


2. Consider the pulley/mass system of question 1(c). The 250 kg mass is released from rest. The drum has rusty bearings with a total friction torque of 120 Nm. With what velocity will the mass strike a floor 6m below its starting position? Use the Power Method and make use of the kinetic energy expression you got in 1(c) to get the downwards acceleration of the mass. [6.97 m/s]

3. The powered lift shown below is required to raise a load mass A (2800 kg) which is also connected by a separate cable over a pair of pulleys (with negligible mass and friction) to a counterweight mass B (2000 kg). Motor E drives gear G through a 9:1 reduction gear ratio. Gear G is rigidly connected to cable drum D which has an effective diameter of 1.2 m. The drive motor and its gear have a combined moment of inertia in rotation of 13.6 kgm^2 while the drum D and its attached gear G have a combined moment of inertia of 85 kgm^2. Show that the System Kinetic Energy for an upwards load velocity V can be written as:

   $$KE = (4048)V^2$$

   Find the motor torque for an upwards acceleration of the load mass of 3.8 m/s^2 [2574 Nm]



4. The uniform circular disc of question 1(a) is rolling down an incline (angle θ). Find its acceleration using Power considerations.

5. The four wheeled trolley of question 1(b) is rolling down a 15° incline. What brake torque must be applied to each rear wheel to keep its speed constant?

6. A car has the following data: Total Mass 1200 kg; Wheel Mass 28 kg; Wheel rolling radius 0.3 m; Wheel Moment of Inertia 1.75 kgm^2; Engine torque 240 Nm; Engine moment of inertia 2.6 kgm^2. Let β be the overall drive ratio, i.e., engine angular velocity = β × (wheel angular velocity). Obtain an expression for the car Kinetic Energy at velocity V in terms of β. [$KE = 0.5\{1278 + 29\,\beta^2\}\,V^2$]

   For a representative car β is 5.29 in third gear and 3.1 in fifth gear. Compare values of car acceleration in third and fifth gear on a level road (ignore air resistance).
   The effect of air resistance is of course too important to ignore in real vehicles. What approximately is the speed dependency of the power lost to air resistance in a vehicle?