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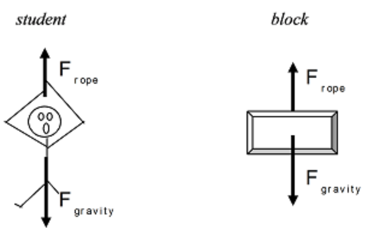
Tired of walking up the stairs, an 80 kg engineering student designs an ingenious device for reaching his third floor dorm room. An 84 kg block is attached to a rope that passes over a pulley. The student holds the other end of the rope. When the 84 kg block is released, the student is pulled up to his dorm room, 8.0 m off the ground.

Free-Body Diagrams

Mathematical Analysis



Event 1: The instant the block is released.

Event 2: The instant the student reaches his room.

Since the distance the student and block travel is known, applying work-energy should allow us to solve the problem. I'll apply it separately to each object.

student

$$\frac{1}{2}mv_i^2 + mgh_i + \Sigma|F||\Delta r|\cos\phi = \frac{1}{2}mv_f^2 + mgh_f$$

$$0 + 0 + F_{rope}(8)\cos 0 = \frac{1}{2}80v_f^2 + 80(9.8)(8)$$

$$8F_{rope} = 40v_f^2 + 6272$$

block

$$\frac{1}{2}mv_i^2 + mgh_i + \Sigma|F||\Delta r|\cos\phi = \frac{1}{2}mv_f^2 + mgh_f$$

$$0 + 84(9.8)(8) + F_{rope}(8)\cos 180 = \frac{1}{2}84v_f^2 + 0$$

$$6586 - 8F_{rope} = 42v_f^2$$

F_{rope} is the same in both equations, as is the final velocity. Thus the two equations can be added together to yield:

$$6586 = 40v_f^2 + 42v_f^2 + 6272$$

$$314 = 82v_f^2$$

$$v_f = 1.96 m/s$$

Notice that if you applied work-energy to the entire system you would have generated this same equation. Initially, the only form of energy present is the gravitational energy of the block (mgh = 6586 J). At the second event, both objects have kinetic energy plus the student has gravitational potential energy (mgh = 6272 J).