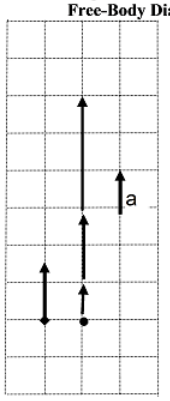
I-88

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.

Motion Diagram



Motion Information

Object: Student

Event 1: Block is released.

$t_1 = 0$ s

$r_1 = 0$ m

$v_1 = 0$ m/s

$a_{12} =$

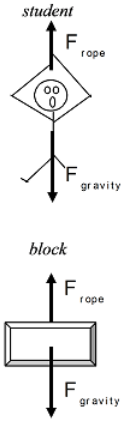
Event 2: Student reaches room.

$t_2 =$

$r_2 = +8.0$ m

$v_2 =$

Free-Body Diagrams



Mathematical Analysis

Since there are three kinematic variables, we will have to analyze the forces first:

student

$$F_{rope} - F_{gravity} = ma$$
$$F_{rope} - (80)(9.8) = 80a_{student}$$

block

$$F_{rope} - F_{gravity} = ma$$
$$F_{rope} - (84)(9.8) = 84a_{block}$$

Because they are tied together, the acceleration of the student and the acceleration of the block are equal in magnitude, but opposite in direction. Therefore, $a_{block} = -a_{student}$.

$$F_{rope} - 784 = 80a_{student}$$
$$F_{rope} = 80a_{student} + 784$$

$$F_{rope} - 823 = 84(-a_{student})$$
$$(80a_{student} + 784) - 823 = -84a_{student}$$
$$164a_{student} = 39$$
$$a_{student} = 0.24 m/s^2$$

We can now complete the kinematic description of the student's motion:

$$8 = 0 + 0(t_2 - 0) + \frac{1}{2}(0.24)(t_2 - 0)^2$$
$$t_2 = 8.18s$$

$$v_2 = 0 + 0.24(8.18 - 0)$$
$$v_2 = 1.96 m/s$$