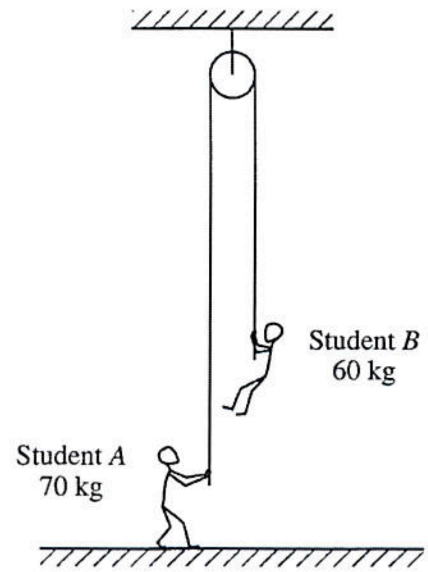


2003B1 (15 points) A rope of negligible mass passes over a pulley of negligible mass attached to the ceiling, as shown above. One end of the rope is held by Student A of mass 70 kg, who is at rest on the floor. The opposite end of the rope is held by Student B of mass 60 kg, who is suspended at rest above the floor.

a. On the dots below that represent the students, draw and label free-body diagrams showing the forces on Student A and on Student B.

• *B*

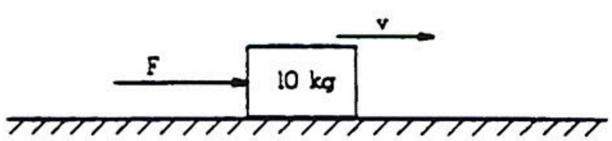
• *A*

b. Calculate the magnitude of the force exerted by the floor on Student A. Student B now climbs up the rope at a constant acceleration of 0.25 m/s^2 with respect to the floor.

c. Calculate the tension in the rope while Student B is accelerating.

d. As Student B is accelerating, is Student A pulled upward off the floor? Justify your answer.

e. With what minimum acceleration must Student B climb up the rope to lift Student A upward off the floor?



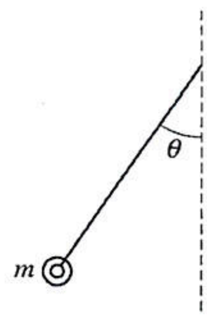
1981B1. A 10-kilogram block is pushed along a rough horizontal surface by a constant horizontal force F as shown above. At time t = 0, the velocity v of the block is 6.0 meters per second in the same direction as the force. The coefficient of sliding friction is 0.2. Assume g = 10 meters per second squared.

a. Calculate the force F necessary to keep the velocity constant.

The force is now changed to a Larger constant value F'. The block accelerates so that its kinetic energy increases by 60 joules while it slides a distance of 4.0 meters.

b. Calculate the force F'.

c. Calculate the acceleration of the block.

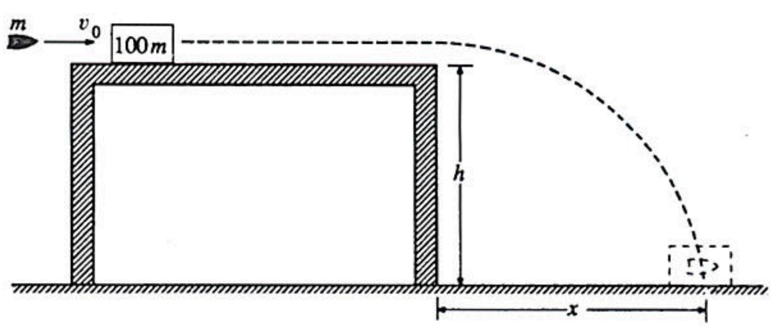


2003Bb1. (15 points) An airplane accelerates uniformly from rest. A physicist passenger holds up a thin string of negligible mass to which she has tied her ring, which has a mass m. She notices that as the plane accelerates down the runway, the string makes an angle θ with the vertical as shown above.

a. In the space below, draw a free-body diagram of the ring, showing and labeling all the forces present.

The plane reaches a takeoff speed of 65 m/s after accelerating for a total of 30 s.

b. Determine the minimum length of the runway needed.
c. Determine the angle θ that the string makes with the vertical during the acceleration of the plane before it leaves the ground.
d. What additional information would be needed in order to estimate the mechanical energy of the airplane at the instant of takeoff? Explain your answer.

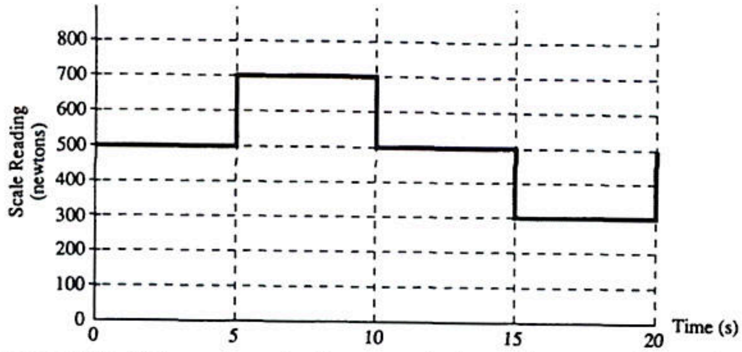


1990B1. A bullet of mass m is moving horizontally with speed v_o when it hits a block of mass 100m that is at rest on a horizontal frictionless table, as shown above. The surface of the table is a height h above the floor. After the impact the bullet and the block slide off the table and hit the floor a distance x from the edge of the table. Derive expressions for the following quantities in terms of m, h, v_o, and appropriate constants:

a. the speed of the block as it leaves the table
b. the change in kinetic energy of the bullet-block system during impact
c. the distance x

Suppose that the bullet passes through the block instead of remaining in it.

d. State whether the time required for the block to reach the floor from the edge of the table would now be greater, less, or the same. Justify your answer.
e. State whether the distance x for the block would now be greater, less, or the same. Justify your answer.



1993B1. A student whose normal weight is 500 newtons stands on a scale in an elevator and records the scale reading as a function of time. The data are shown in the graph above. At time t = 0, the elevator is at displacement x = 0 with velocity v = 0. Assume that the positive directions for displacement, velocity, and acceleration are upward.

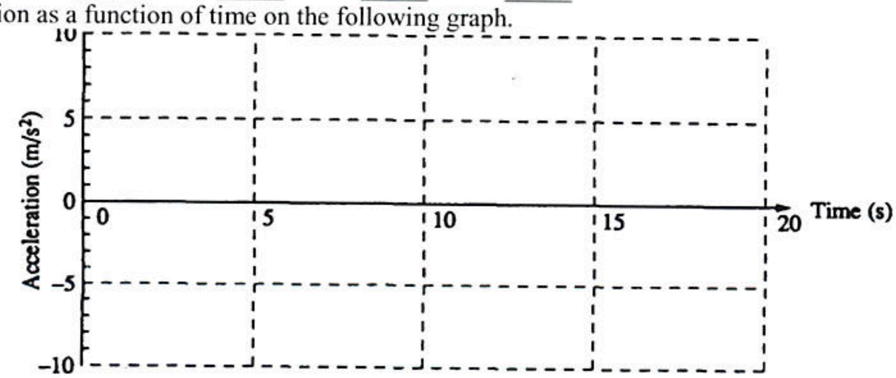
a. On the diagram below, draw and label all of the forces on the student at t = 8 seconds.

b. Calculate the acceleration a of the elevator for each 5-second interval.

i. Indicate your results by completing the following table.

Time Interval (s)	0–5	5–10	10–15	15–20
a ($m|s^2$)	____	____	____	____

ii. Plot the acceleration as a function of time on the following graph.

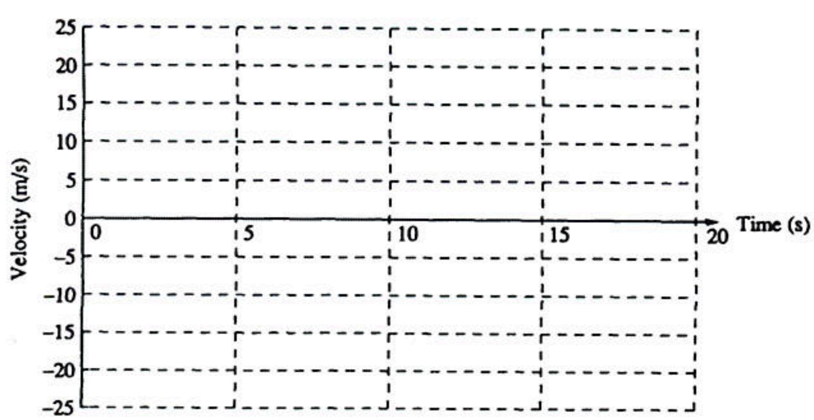


c. Determine the velocity v of the elevator at the end of each 5-second interval.

i. Indicate your results by completing the following table.

Time Interval (s)	0–5	5–10	10–15	15–20
v (m/s)	____	____	____	____

ii. Plot the velocity as a function of time on the following graph.

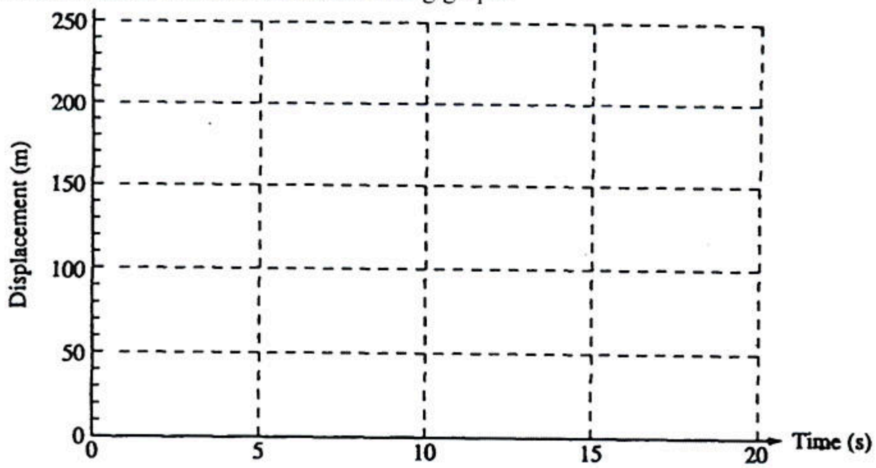


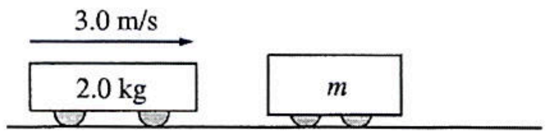
d. Determine the displacement x of the elevator above the starting point at the end of each 5-second interval.

i. Indicate your results by completing the following table.

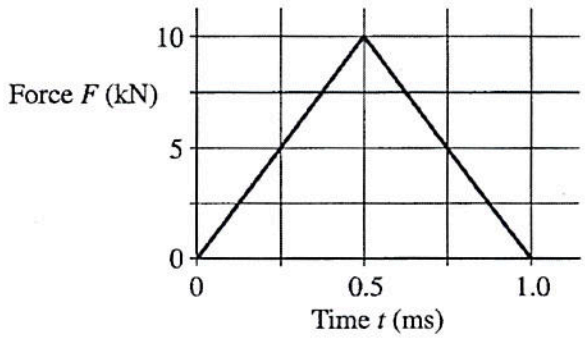
Time Interval (s)	0–5	5–10	10–15	15–20
x (m)	_____	_____	_____	_____

ii. Plot the displacement as a function of time on the following graph.





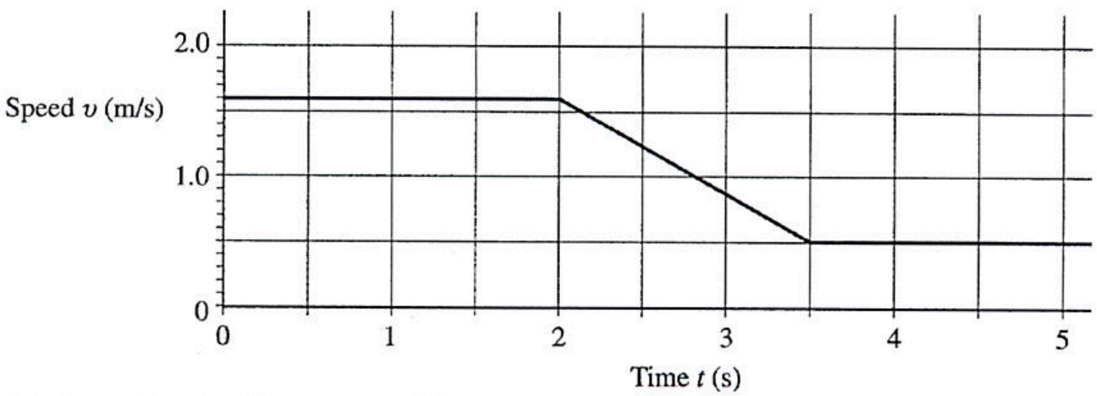
2002B1B (15 points) A 2.0 kg frictionless cart is moving at a constant speed of 3.0 m/s to the right on a horizontal surface, as shown above, when it collides with a second cart of undetermined mass m that is initially at rest. The force F of the collision as a function of time t is shown in the graph below, where $t = 0$ is the instant of initial contact. As a result of the collision, the second cart acquires a speed of 1.6 m/s to the right. Assume that friction is negligible before, during, and after the collision.



(a) Calculate the magnitude and direction of the velocity of the 2.0 kg cart after the collision.

(b) Calculate the mass m of the second cart.

After the collision, the second cart eventually experiences a ramp, which it traverses with no frictional losses. The graph below shows the speed v of the second cart as a function of time t for the next 5.0 s, where $t = 0$ is now the instant at which the carts separate.



(c) Calculate the acceleration of the cart at $t = 3.0$ s.

(d) Calculate the distance traveled by the second cart during the 5.0 s interval after the collision (0 s $< t <$ 5.0 s).

(e) State whether the ramp goes up or down and calculate the maximum elevation (above or below the initial height) reached by the second cart on the ramp during the 5.0 s interval after the collision (0 s $< t <$ 5.0 s).