

Physics 1A Discussion (Week 5)

Problem 1 (problem 4.38 on page 126 of the textbook)

CP Two blocks connected by a light horizontal rope sit at rest on a horizontal, frictionless surface. Block A has mass 15.0 kg, and block B has mass m . A constant horizontal force $F = 60.0$ N is applied to block A (Fig. P4.38). In the first 5.00 s after the force is applied, block A moves 18.0 m to the right. (a) While the blocks are moving, what is the tension T in the rope that connects the two blocks? (b) What is the mass of block B?

(a) We know that the system as a 60N force applied to it. That is both block A and block B so,

$$F = (15kg + m)a = 60N$$

The system is pushed 18 m in 5 seconds. This is a constant force so we can use kinematics,

$$x(t) = \frac{1}{2}at^2$$

We can solve for a here by plugging those quantities in,

$$18 = \frac{1}{2}a(5)^2$$

$$a = 1.44 \frac{m}{s^2}$$

To find the tension on rope connecting the blocks we can observe that the net force on A is given by,

$$F_a = 15 * 1.44N$$

This is just the some of the forces acting on the block,

$$F_a = F - F_T$$

$$15 * 1.44 = 60 - F_T$$

Solving for F_T we get,

$$F_T = 38N$$

(b) Using our first equation we know that,

$$F = (15kg + m)a$$

Plugging in a and F then solving for m we get,

$$60 = (15 + m)1.44$$

$$m = 26.7kg$$

Problem 2 (problem 4.47 on page 126 of the textbook)

CP A small rocket with mass 20.0 kg is moving in free fall toward the earth. Air resistance can be neglected. When the rocket is 80.0 m above the surface of the earth, it is moving downward with a speed of 30.0 m/s. At that instant the rocket engines start to fire and produce a constant upward force F on the rocket. Assume the change in the rocket's mass is negligible. What is the value of F if the rocket's speed becomes zero just as it reaches the surface of the earth, for a soft landing? (Hint: The net force on the rocket is the combination of the upward force F from the engines and the downward weight of the rocket.)

There is a way to do this problem with kinematics but it is a lot more straight forward to use an energy formulation of the problem,

We know that the energy in a gravitational field is given by kinetic T plus potential U ,

$$E = T + U = \frac{1}{2}mv^2 + mgh$$

We know that energy must be accounted for in work so,

$$E_i = E_f + W$$

We know that the final height and velocity of the rocket should be both zero so $E_f = 0$.

$$E_i = W = \vec{F} \cdot \vec{x} = Fh$$

Since h , m and v are given initially we can just solve for F here,

$$\frac{1}{2}mv^2 + mgh = Fh$$

$$\frac{1}{2}(20)(30)^2 + (20)g(80) = F(80)$$

Solving for F we get,

$$F = 308.5N$$

Problem 3 (problem 4.56 on page 126 of the textbook)

An object of mass m is at rest in equilibrium at the origin. At $t = 0$ a new force $\vec{F}(t)$ is applied that has components

$$F_x(t) = k_1 + k_2 y \quad F_y(t) = k_3 t$$

where k_1 and k_2 are constants. Calculate the position $\vec{r}(t)$ and velocity $\vec{v}(t)$ vectors as functions of time.

Since F_x is in terms of y , let's calculate the y components first,

$$F_y(t) = m y'' = k_3 t$$

Integrating we get,

$$V_y(t) = \frac{k_3}{m} \frac{t^2}{2}$$

Integrating once more we get y ,

$$y(t) = \frac{k_3}{m} \frac{t^3}{6}$$

Now we get the x component,

$$F_x(t) = k_1 + k_2 y = k_1 + k_2 \left(\frac{k_3}{6m} t^3 \right)$$

$$m x'' = k_1 + k_2 \left(\frac{k_3}{6m} t^3 \right)$$

Integrating we get,

$$V_x(t) = \left(k_1 t + k_2 \left(\frac{k_3}{24m} t^4 \right) \right) / m$$

Integrating once more we get x ,

$$x(t) = \frac{1}{2m} \left(k_1 t^2 + \frac{k_2 k_3}{60m} t^5 \right)$$

$\vec{r}$ and $\vec{v}$ just equal vectors with these components,

$$\vec{r} = (x(t), y(t))$$

$$\vec{V} = (V_x(t), V_y(t))$$

Problem 4 (problem 5.62 on page 164 of the textbook)

In Fig. P5.62 a worker lifts a weight w by pulling down on a rope with a force $\vec{F}$. The upper pulley is attached to the ceiling by a chain, and the lower pulley is attached to the weight by another chain. Draw one or more free-body diagrams to find the tension in each chain and the magnitude of $\vec{F}$, in terms of w , if the weight is lifted at constant speed. Assume that the rope, pulleys, and chains have negligible weights.

Since this is a single massless rope we can be certain that the tension is equal throughout,

$$T_1 = T_2 = F$$

The weight is moving at a constant velocity so it is in force equilibrium.

We know that the tension of both sides of the rope is pulling with the same force as the weight so,

$$T_1 + T_2 = W$$

$$T_1 + T_1 = W$$

$$2T_1 = W$$

$$T_1 = W/2$$

Since we know that the force is equal to the tension,

$$F = W/2$$