| Planet | Radius | Mass | Acceleration due to gravity |
|---|---|---|---|
| Mercury | 0.379 | 0.056 | 0.36 |
| Venus | 0.972 | 0.817 | 0.87 |
| Earth | 1.000 | 1.000 | 1.00 |
| Mars | 0.533 | 0.108 | 0.38 |
| Jupiter | 11.190 | 318 | 2.64 |
| Saturn | 9.470 | 95.2 | 1.13 |
| Uranus | 3.689 | 14.6 | 1.07 |
| Neptune | 3.496 | 17.3 | 1.41 |

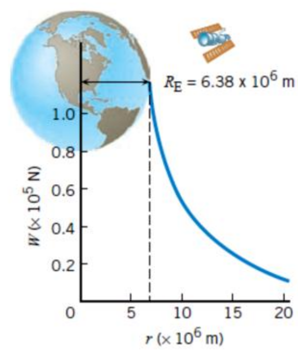
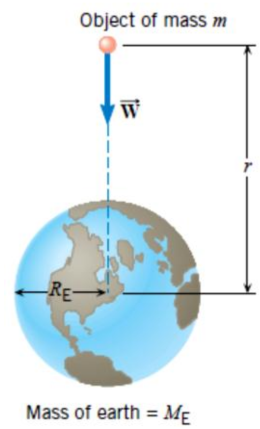
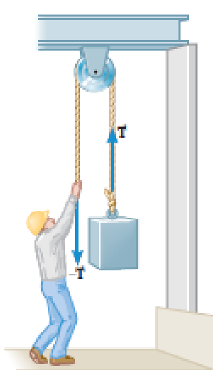
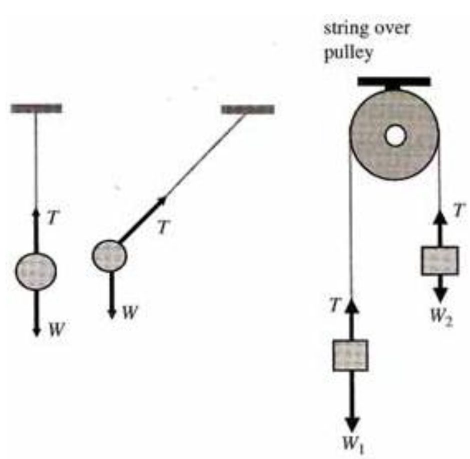


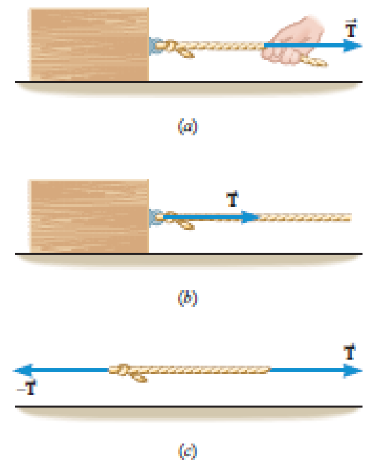

**Figure 4.12** The weight of the Hubble Space Telescope decreases as the telescope gets farther from the earth. The distance from the center of the earth to the telescope is $r$.

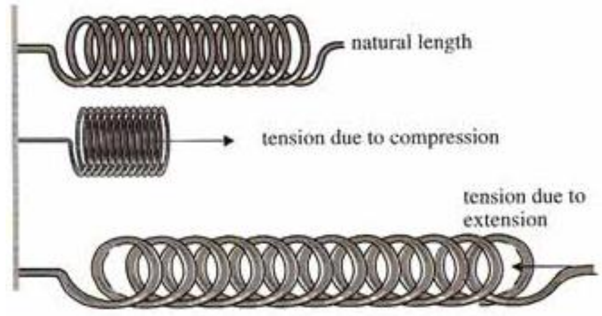


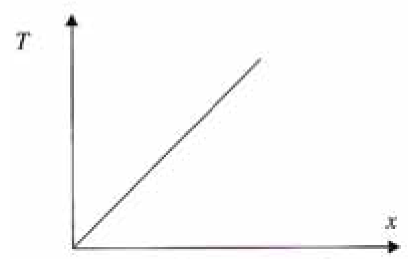

## TENSION



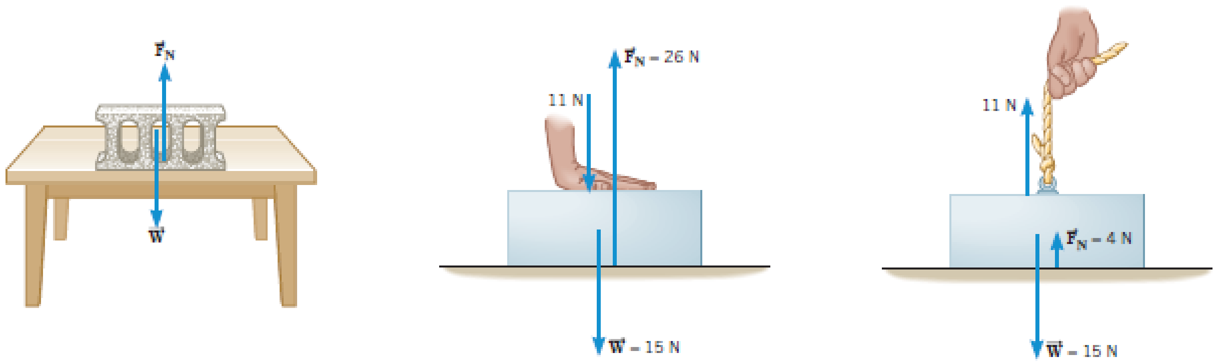





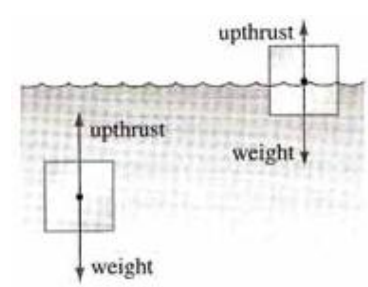




## NORMAL FORCES

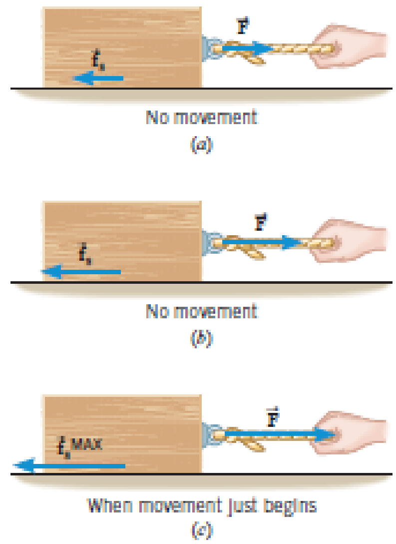



## DRAG FORCES

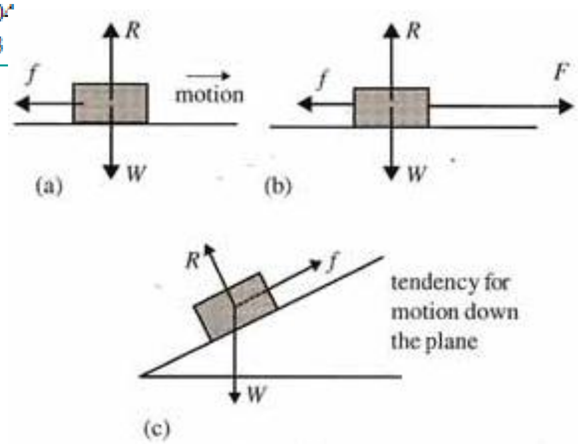

## UPTHRUST



## FRICTIONAL FORCES




| Materials | Coefficient of Static Friction, $\mu_s$ | Coefficient of Kinetic Friction, $\mu_k$ |
|---|---|---|
| Glass on glass (dry) | 0.94 | 0.4 |
| Ice on ice (clean, 0 °C) | 0.1 | 0.02 |
| Rubber on dry concrete | 1.0 | 0.8 |
| Rubber on wet concrete | 0.7 | 0.5 |
| Steel on ice | 0.1 | 0.05 |
| Steel on steel (dry hard steel) | 0.78 | 0.42 |
| Teflon on Teflon | 0.04 | 0.04 |
| Wood on wood | 0.35 | 0.3 |



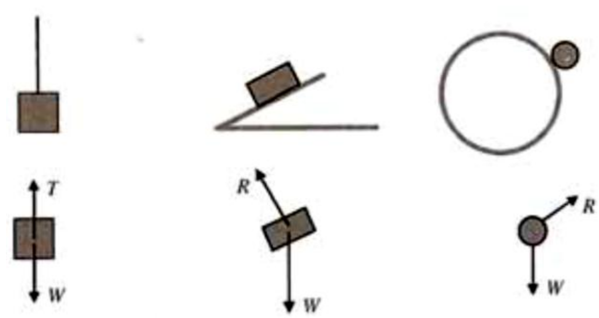




**Figure 3.9** Free-body diagrams for the bodies in dark grey.

EXAMPLE

A cup of coffee is sitting on a table in a recreational vehicle (RV). The cup slides toward the rear of the RV. According to Newton's first law, which one or more of the following statements could describe the motion of the RV?

*(A) The RV is at rest, and the driver suddenly accelerates.*
*(B) The RV is moving forward, and the driver suddenly accelerates.*
*(C) The RV is moving backward, and the driver suddenly hits the brakes.*

**A.** A **B.** B **C.** C **D.** A and B **E.** A, B, and C

**DO HW/STUDY PACKET #2,4**

**DO HW/STUDY GUIDE #5,6**

EXAMPLE

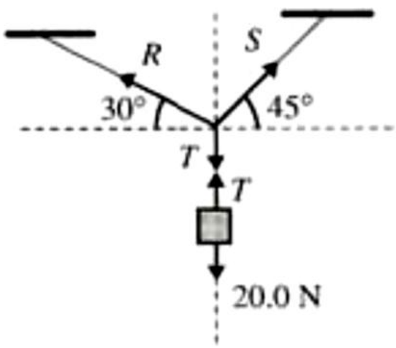
The diagram shows a girl attempting (but failing) to lift a heavy suitcase of weight *W.* The magnitude of the vertical upwards pull of the girl on the suitcase is *P* and the magnitude of the vertical reaction of the floor on the suitcase is *R*.
Write an equation correctly relates *W*, *P* and *R*. **[*W* = *P* + *R*]**

EXAMPLE

A skydiver of mass 80 kg falls vertically with a constant speed of 50 $ms^{-1}$. Determine the upward force acting on the skydiver. **[Around 800 N]**

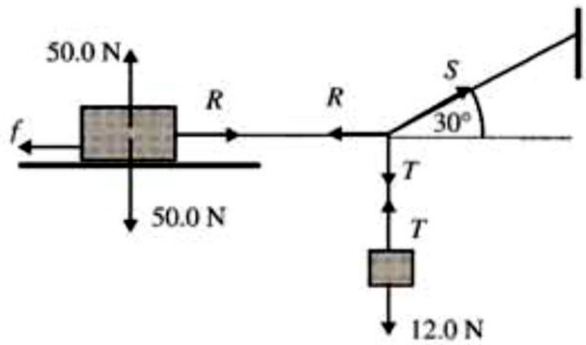
EXAMPLE

A 20.0 N weight hangs from strings as shown. Find the tension in each string.
**[R = 14.6 N, S = 17.9 N, T = 20.0 N]**



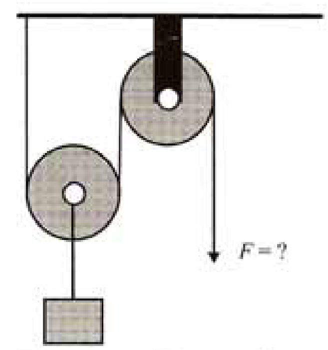
EXAMPLE

A block of weight 50.0 N rests on a rough horizontal table and is attached by strings to a hanging mass of weight 12.0 N. Find the force of friction between the block and the table if the block on the table is in equilibrium. **[f = 20.8 N]**

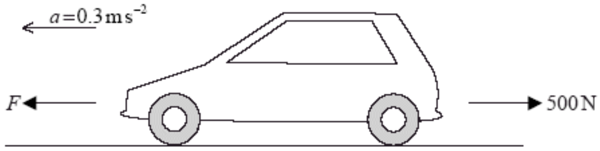



EXAMPLE

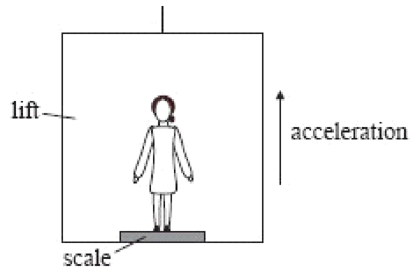
A weight of mass 500.0 g hangs from very light, smooth pulleys as shown. What force must be applied to the rope so that the mass stays at rest? **[about 2.5 N]**



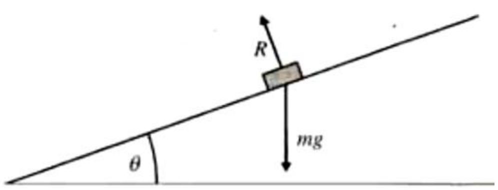
EXAMPLE
A car of mass 1000 kg accelerates on a straight, flat, horizontal road with an acceleration *a* = 0.3 m $s^{-2}$. The driving force *F* on the car is opposed by a resistive force of 500 N. What is the net (resultant) force on the car? **[300 N]**




EXAMPLE
Mandy stands on a weighing scale inside a lift (elevator) that accelerates vertically upwards as shown in the diagram below. The forces on Mandy are her weight *W* and the reaction force from the scale *R*. Determine the reading on the scale. **[R]**




EXAMPLE
A mass m = 2.0 kg is held on a frictionless plane inclined at 30°. What is the acceleration of the mass when released? **[5.0 $ms^{-2}$]**

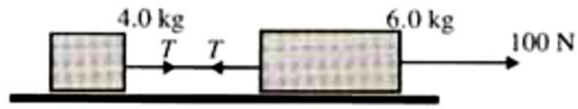



EXAMPLE
A frictionless trolley of mass *m* moves down a slope with a constant acceleration *a*. A second similar frictionless trolley has mass 2*m*. What is the acceleration of the second trolley as it moves down the slope? **[a]**

**DO HW/STUDY PACKET #9,13**

EXAMPLE

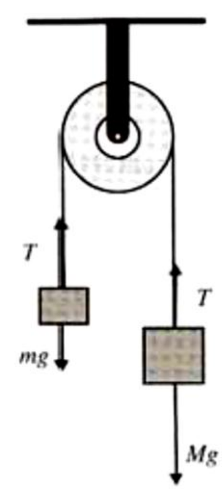
Two blocks, of mass 4.0 and 6.0 kg are joined by a string and rest on a frictionless horizontal table. If a force of 100 N is applied horizontally on one of the blocks, find the acceleration of each block and the tension in the string.




**[a = 10 ms$^{-2}$, T = 40 N]**

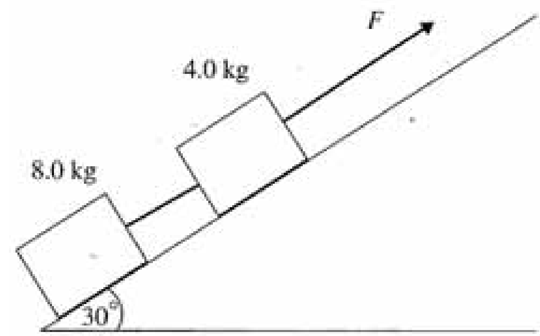
EXAMPLE

Two masses of m = 4.0 kg and M = 6.0 kg are joined together by a string that passes over a pulley. The masses are held stationary and suddenly released. What is the acceleration of each mass and the tension in the string? (This is called an 'Atwood's Machine'). **[a = 2.0 ms$^{-2}$, T = 48 N]**



EXAMPLE

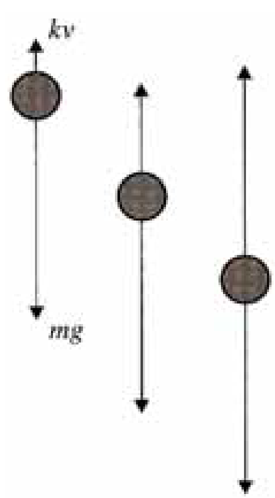
Two blocks are joined by a string and are pulled up an inclined plane that makes an angle of 30° to the horizontal. Calculate the tension in the string when:

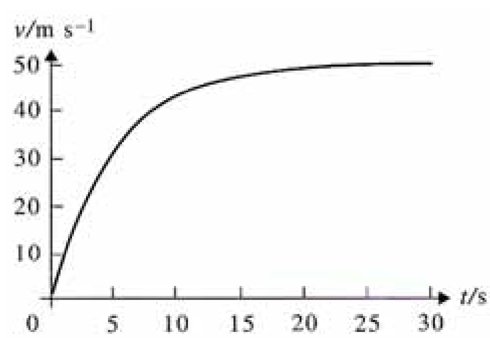


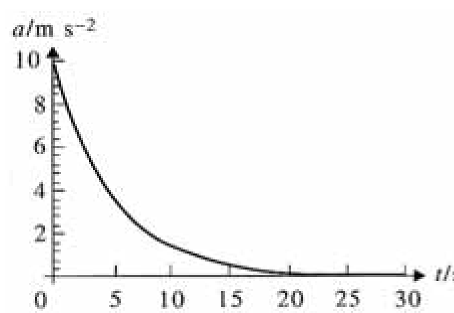

a) The bodies move with constant speed. **[40 N]**

b) The bodies move up the plane with an acceleration of 2.0 $ms^{-2}$. **[56 N]**

c) What is the value of F in each case. **[60 N, 84 N]**



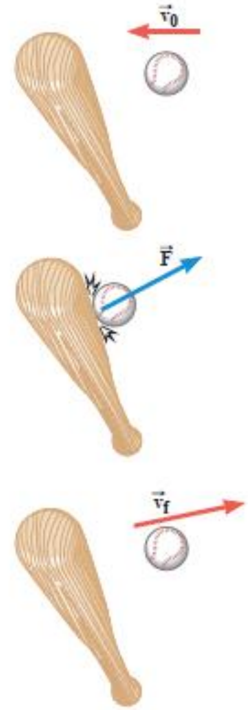




**DO HW #14**

EXAMPLE

A baseball ($m$ = 0.14 kg) has an initial velocity of **u** = -38 m/s as it approaches a bat. The bat applies an average force that is much larger than the weight of the ball, and the ball departs from the bat with a final velocity of **v** = +58 m/s.




a) Determine the impulse applied to the ball by the bat. **[+13.4 kg m s$^{-1}$]**

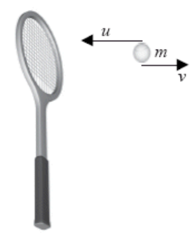
b) Assuming that the time of contact is $t$ = 1.6 x 10$^{-3}$ s, find the average force exerted on the ball by the bat. **[+8400 N]**

c) Find the average force exerted by the bat on the ball. **[-8400 N]**

EXAMPLE

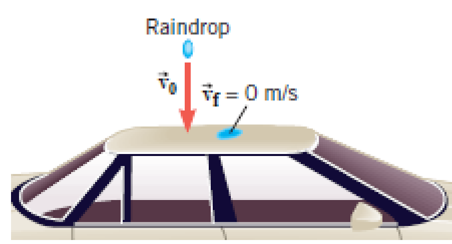
A tennis ball of mass $m$ moving horizontally with speed $u$ strikes a vertical tennis racket. The ball bounces back with a horizontal speed $v$. Determine the magnitude of the change in momentum of the ball in terms of the given variables.

**[$m$ ($u$ + $v$)]**




EXAMPLE

During a storm, rain comes straight down with a velocity of 15 m/s and hits the roof of a car perpendicularly. The mass of rain per second that strikes the car roof is 0.060 kg s$^{-1}$.




a) Assuming that the rain comes to rest upon striking the car find the average force exerted by the rain on the roof. **[0.90 N]**

b) Instead of rain, suppose hail is falling. The hail comes straight down at a mass rate of $m/\Delta t$ = 0.060 kg s$^{-1}$ and an initial velocity of 15 m/s and bounces off the roof perpendicularly. Would the force on the roof of the car be different than in part (a)? Explain.

***Tsokos, p 88 Q2***

**Q2**

A 0.50 kg ball bounces vertically off a hard surface. A graph of velocity versus time is shown in Figure 6.2. Find the magnitude of the momentum change of the ball during the bounce. The ball stayed in contact with floor for 0.15 s. What average force did the ball exert on the floor?

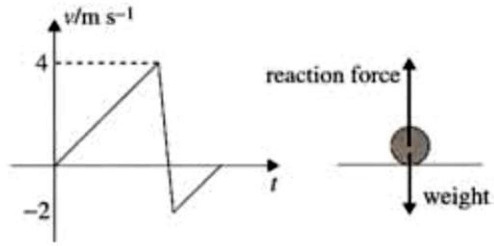



**Figure 6.2.**

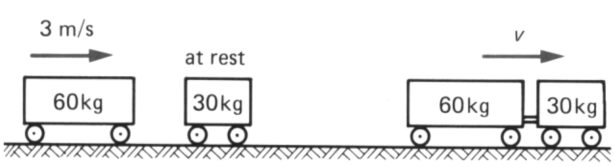
***Tsokos, p 88 Q3***

**Q3**

Bullets of mass 30 g are being fired from a gun with a speed of 300 m $s^{-1}$ at a rate of 20 per second. What force is being exerted on the gun?

<u>EXAMPLE</u>

Find the velocity of both cars below after the collision, assuming that they stick together. Is the collision elastic? If not, how much kinetic energy is lost? **[+2 ms$^{-1}$, 90 J lost]**



***Tsokos, p 94 Q16***

**Q16**

(a) A man of mass $m$ stands on a cart of mass $M$ that rests on a horizontal frictionless surface. If the man begins to walk with velocity $v$ *with respect to the cart,* how will the cart move? See Figure 6.13.

(b) What happens when the man gets to the edge of the cart and stops walking?

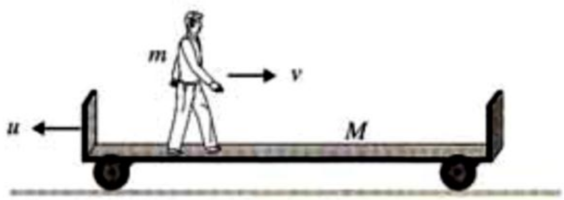


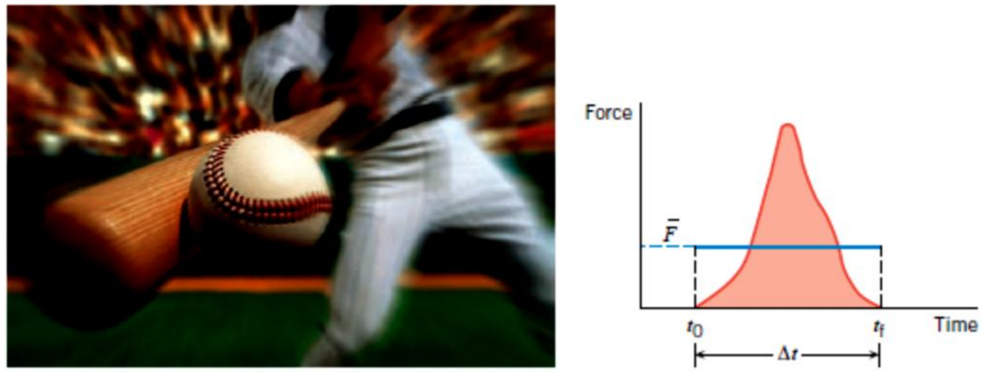

**Figure 6.13.**

***Tsokos, p 94 Q17***

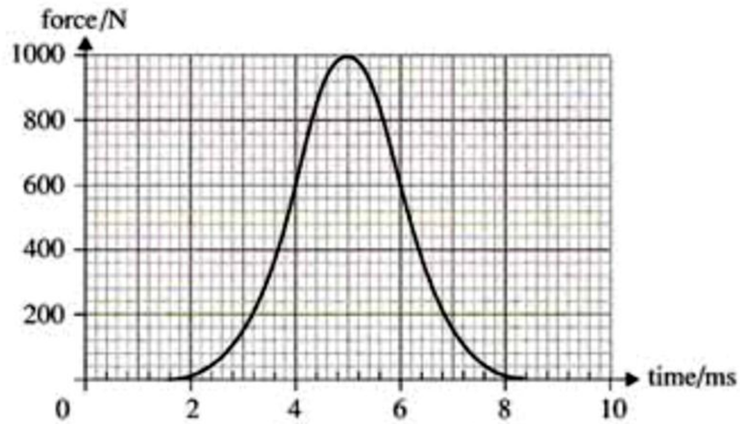
**Q17**

A cart of mass $M$ moves with constant velocity $v$ on a frictionless road (see Figure 6.14). Rain is falling vertically on to the road and begins to fill the cart at a steady rate of $\mu$ kg per second. Find the velocity of the cart $t$ seconds later.


**Figure 6.14.**




(a) (b)



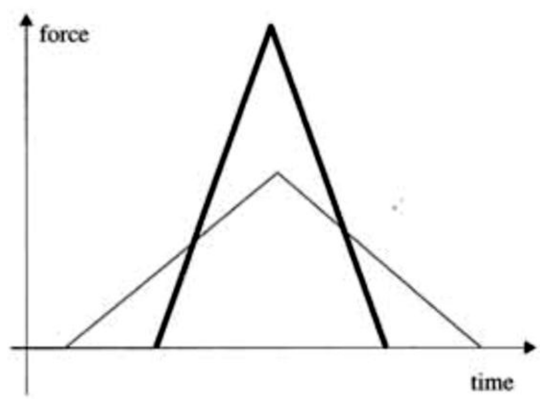




**Figure 6.6** The areas under the two curves are the same so the force acting for a shorter time must be larger on average.

**DO HW #17, 18**