QUESTIONS

To convert from ft^2 to yd^2, you should

(*a*) multiply by 3.
(*b*) multiply by 1/3.
(*c*) multiply by 9.
(*d*) multiply by 1/9.
(*e*) multiply by 6.
(*f*) multiply by 1/6.

Answer: D

QUESTIONS

17. (II) A typical atom has a diameter of about 1.0×10^{-10} m. (*a*) What is this in inches? (*b*) Approximately how many atoms are along a 1.0-cm line, assuming they just touch?

17. (*a*) $1.0\times10^{-10}\text{ m} = (1.0\times10^{-10}\text{ m})(39.37\text{ in/1 m}) = \boxed{3.9\times10^{-9}\text{ in}}$

(*b*) $(1.0\text{ cm})\left(\dfrac{1\text{ m}}{100\text{ cm}}\right)\left(\dfrac{1\text{ atom}}{1.0\times10^{-10}\text{ m}}\right) = \boxed{1.0\times10^{8}\text{ atoms}}$

21. (II) American football uses a field that is 100.0 yd long, whereas a soccer field is 100.0 m long. Which field is longer, and by how much (give yards, meters, and percent)?

21. Since the meter is longer than the yard, the soccer field is longer than the football field.

$$\ell_{\text{soccer}} - \ell_{\text{football}} = 100.0\text{ m} \times \frac{1.094\text{ yd}}{1\text{ m}} - 100.0\text{ yd} = \boxed{9.4\text{ yd}}$$

$$\ell_{\text{soccer}} - \ell_{\text{football}} = 100.0\text{ m} - 100.0\text{ yd} \times \frac{1\text{ m}}{1.094\text{ yd}} = \boxed{8.6\text{ m}}$$

Since the soccer field is 109.4 yd compared with the 100.0-yd football field, the soccer field is $\boxed{9.4\%}$ longer than the football field.

33. (III) I agree to hire you for 30 days. You can decide between two methods of payment: either (1) \$1000 a day, or (2) one penny on the first day, two pennies on the second day and continue to double your daily pay each day up to day 30. Use quick estimation to make your decision, and justify it.

34. (III) Many sailboats are docked at a marina 4.4 km away on the opposite side of a lake. You stare at one of the sailboats because, when you are lying flat at the water's edge, you can just see its deck but none of the side of the sailboat. You then go to that sailboat on the other side of the lake and measure that the deck is 1.5 m above the level of the water. Using Fig. 1–16, where $h = 1.5$ m, estimate the radius R of the Earth.

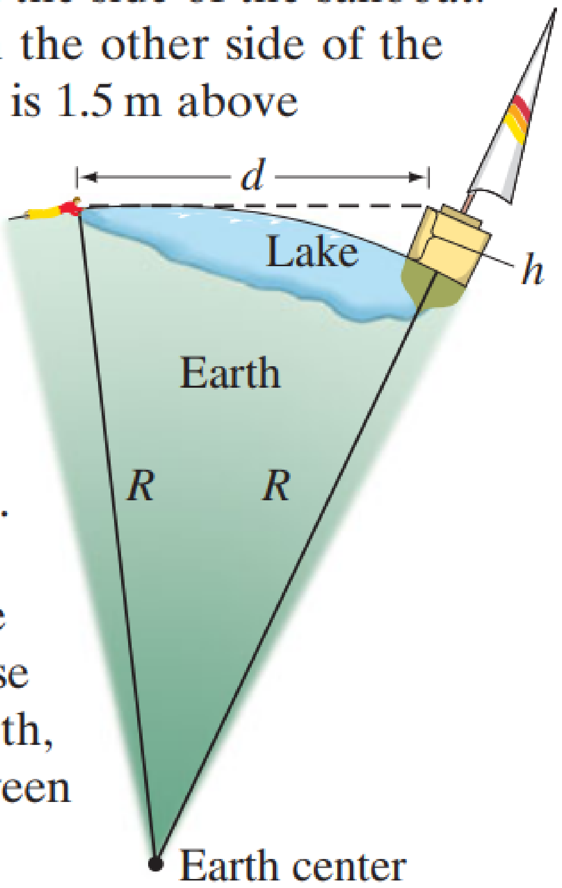


FIGURE 1–16 Problem 34. You see a sailboat across a lake (not to scale). R is the radius of the Earth. Because of the curvature of the Earth, the water "bulges out" between you and the boat.

33. At \$1,000 per day, you would earn \$30,000 in the 30 days. With the other pay method, you would get $\$0.01(2^{t-1})$ on the tth day. On the first day, you get $\$0.01(2^{1-1}) = \$0.01$. On the second day, you get $\$0.01(2^{2-1}) = \$0.02$. On the third day, you get $\$0.01(2^{3-1}) = \$0.04$. On the 30th day, you get $\$0.01(2^{30-1}) = \$5.4\times10^{6}$, which is over 5 million dollars. Get paid by the $\boxed{\text{second method}}$.

34. In the figure in the textbook, the distance d is perpendicular to the radius that is drawn approximately vertically. Thus there is a right triangle, with legs of d and R, and a hypotenuse of $R+h$. Since $h \ll R$, $h^2 \ll 2Rh$.

$$d^2 + R^2 = (R+h)^2 = R^2 + 2Rh + h^2 \rightarrow d^2 = 2Rh + h^2 \rightarrow d^2 \approx 2Rh \rightarrow R = \frac{d^2}{2h}$$

$$= \frac{(4400\text{ m})^2}{2(1.5\text{ m})} = \boxed{6.5\times10^6\text{ m}}$$

A better measurement gives $R = 6.38\times10^6$ m.

48. Hold a pencil in front of your eye at a position where its blunt end just blocks out the Moon (Fig. 1–19). Make appropriate measurements to estimate the diameter of the Moon, given that the Earth–Moon distance is 3.8×10^5 km.

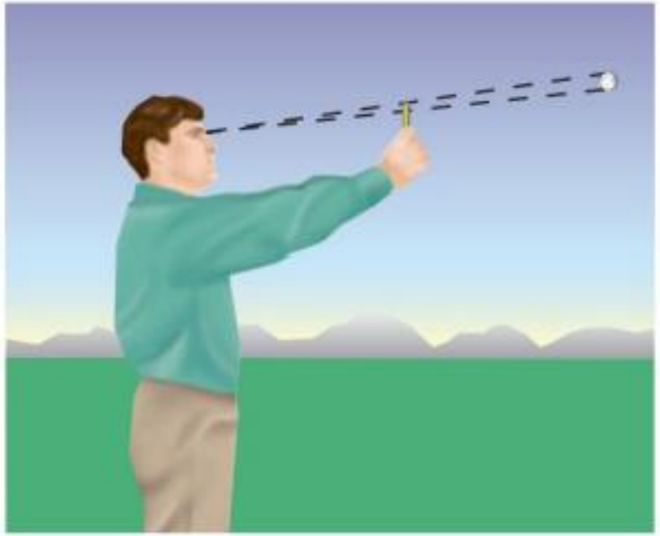
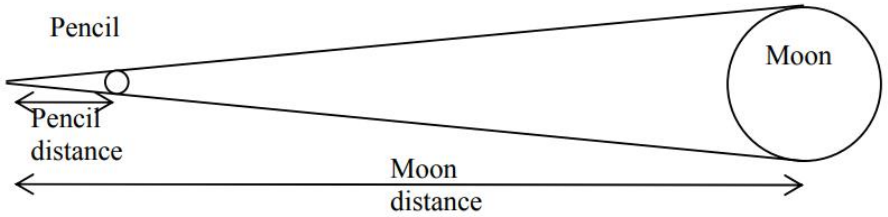


FIGURE 1–19
Problem 48. How big is the Moon?

48. A pencil has a diameter of about 0.7 cm. If held about 0.75 m from the eye, it can just block out the Moon. The ratio of pencil diameter to arm length is the same as the ratio of Moon diameter to Moon distance. From the diagram, we have the following ratios.



$$\frac{\text{Pencil diameter}}{\text{Pencil distance}} = \frac{\text{Moon diameter}}{\text{Moon distance}} \rightarrow$$

$$\text{Moon diameter} = \frac{\text{Pencil diameter}}{\text{Pencil distance}}(\text{Moon distance}) = \frac{7 \times 10^{-3}\text{ m}}{0.75\text{ m}}(3.8 \times 10^5\text{ km}) \approx \boxed{3500\text{ km}}$$

The actual value is 3480 km.

5. (I) A bird can fly 25 km/h. How long does it take to fly 3.5 km?

5. The time of travel can be found by rearranging the average velocity equation.

$$\bar{v} = \Delta x/\Delta t \quad \rightarrow \quad \Delta t = \Delta x/\bar{v} = (3.5\ \text{km})/(25\ \text{km/h}) = \boxed{0.14\ \text{h}} = 8.4\ \text{min}$$

7. (II) You are driving home from school steadily at 95 km/h for 180 km. It then begins to rain and you slow to 65 km/h. You arrive home after driving 4.5 h. (*a*) How far is your hometown from school? (*b*) What was your average speed?

7. The time for the first part of the trip is calculated from the initial speed and the first distance, using d to represent distance.

$$\bar{v}_1 = \frac{d_1}{\Delta t_1} \rightarrow \Delta t_1 = \frac{d_1}{\bar{v}_1} = \frac{180\ \text{km}}{95\ \text{km/h}} = 1.895\ \text{h} = 113.7\ \text{min}$$

The time for the second part of the trip is now calculated.

$$\Delta t_2 = \Delta t_{\text{total}} - \Delta t_1 = 4.5\ \text{h} - 1.895\ \text{h} = 2.605\ \text{h} = 156.3\ \text{min}$$

The distance for the second part of the trip is calculated from the average speed for that part of the trip and the time for that part of the trip.

$$\bar{v}_2 = \frac{d_2}{\Delta t_2} \rightarrow d_2 = \bar{v}_2 \Delta t_2 = (65\ \text{km/h})(2.605\ \text{h}) = 169.3\ \text{km} \approx 170\ \text{km}$$

(*a*) The total distance is then $d_{\text{total}} = d_1 + d_2 = 180\ \text{km} + 169.3\ \text{km} = 349.3\ \text{km} \approx \boxed{350\ \text{km}}$.

(*b*) The average speed is NOT the average of the two speeds. Use the definition of average speed, Eq. 2–1.

$$\bar{v} = \frac{d_{\text{total}}}{\Delta t_{\text{total}}} = \frac{349.3\ \text{km}}{4.5\ \text{h}} = 77.62\ \text{km/h} \approx \boxed{78\ \text{km/h}}$$

9. (II) A person jogs eight complete laps around a 400-m track in a total time of 14.5 min. Calculate (*a*) the average speed and (*b*) the average velocity, in m/s.

9. The distance traveled is 3200 m (8 laps × 400 m/lap). That distance probably has either 3 or 4 significant figures, since the track distance is probably known to at least the nearest meter for competition purposes. The displacement is 0, because the ending point is the same as the starting point.

(*a*) $\text{Average speed} = \dfrac{d}{\Delta t} = \dfrac{3200\text{ m}}{14.5\text{ min}}\left(\dfrac{1\text{ min}}{60\text{ s}}\right) = \boxed{3.68\text{ m/s}}$

(*b*) $\text{Average velocity} = \bar{v} = \Delta x/\Delta t = \boxed{0\text{ m/s}}$

11. (II) A car traveling 95 km/h is 210 m behind a truck traveling 75 km/h. How long will it take the car to reach the truck?

11. Both objects will have the same time of travel. If the truck travels a distance d_{truck}, then the distance the car travels will be $d_{\text{car}} = d_{\text{truck}} + 210\ \text{m}$. Using the equation for average speed, $\bar{v} = d/\Delta t$, solve for time, and equate the two times.

$$\Delta t = \frac{d_{\text{truck}}}{\bar{v}_{\text{truck}}} = \frac{d_{\text{car}}}{\bar{v}_{\text{car}}} \qquad \frac{d_{\text{truck}}}{75\ \text{km/h}} = \frac{d_{\text{truck}} + 210\ \text{m}}{95\ \text{km/h}}$$

Solving for d_{truck} gives $d_{\text{truck}} = (210\ \text{m})\dfrac{(75\ \text{km/h})}{(95\ \text{km/h} - 75\ \text{km/h})} = 787.5\ \text{m}$.

The time of travel is

$$\Delta t = \frac{d_{\text{truck}}}{\bar{v}_{\text{truck}}} = \left(\frac{787.5\ \text{m}}{75{,}000\ \text{m/h}}\right)\left(\frac{60\ \text{min}}{1\ \text{h}}\right) = 0.63\ \text{min} = 37.8\ \text{s} \approx \boxed{38\ \text{s}}$$

Also note that $\Delta t = \dfrac{d_{\text{car}}}{\bar{v}_{\text{car}}} = \left(\dfrac{787.5\ \text{m} + 210\ \text{m}}{95{,}000\ \text{m/h}}\right)\left(\dfrac{60\ \text{min}}{1\ \text{h}}\right) = 0.63\ \text{min} = 37.8\ \text{s}$.

ALTERNATE SOLUTION:

The speed of the car relative to the truck is $95\ \text{km/h} - 75\ \text{km/h} = 20\ \text{km/h}$. In the reference frame of the truck, the car must travel 210 m to catch it.

$$\Delta t = \frac{0.21\ \text{km}}{20\ \text{km/h}}\left(\frac{3600\ \text{s}}{1\ \text{h}}\right) = 37.8\ \text{s}$$

16. (III) An automobile traveling 95 km/h overtakes a 1.30-km-long train traveling in the same direction on a track parallel to the road. If the train's speed is 75 km/h, how long does it take the car to pass it, and how far will the car have traveled in this time? See Fig. 2–36. What are the results if the car and train are traveling in opposite directions?

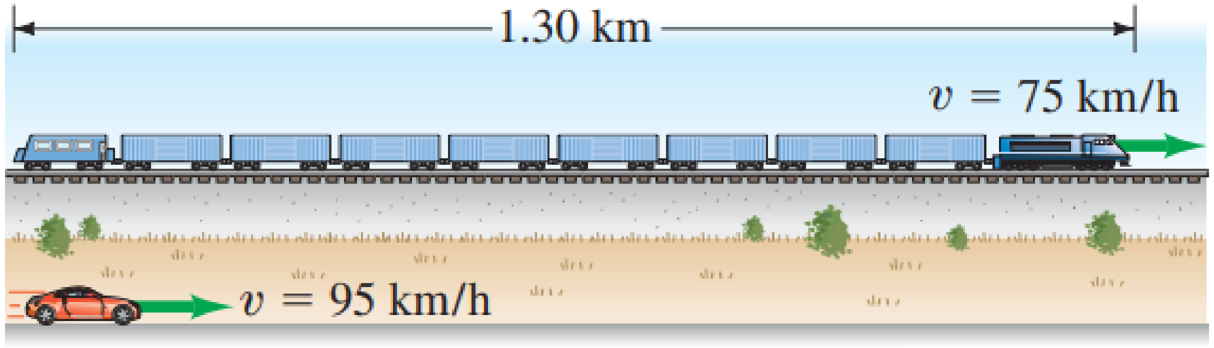


FIGURE 2–36 Problem 16.

2–4 Acceleration

17. (I) A sports car accelerates from rest to 95 km/h in 4.3 s. What is its average acceleration in m/s^2?

16. For the car to pass the train, the car must travel the length of the train AND the distance the train travels. The distance the car travels can thus be written as either $d_{car} = v_{car}t = (95\text{ km/h})t$ or $d_{car} = \ell_{train} + v_{train}t = 1.30\text{ km} + (75\text{ km/h})t$. To solve for the time, equate these two expressions for the distance the car travels.

$$(95\text{ km/h})t = 1.30\text{ km} + (75\text{ km/h})t \;\rightarrow\; t = \frac{1.30\text{ km}}{20\text{ km/h}} = 0.065\text{ h} = \boxed{3.9\text{ min}}$$

Note that this is the same as calculating from the reference frame of the train, in which the car is moving at 20 km/h and must travel the length of the train.

The distance the car travels during this time is $d = (95\text{ km/h})(0.065\text{ h}) = 6.175\text{ km} \approx \boxed{6.2\text{ km}}$.

If the train is traveling in the opposite direction from the car, then the car must travel the length of the train MINUS the distance the train travels. Thus the distance the car travels can be written as either $d_{car} = (95\text{ km/h})t$ or $d_{car} = 1.30\text{ km} - (75\text{ km/h})t$. To solve for the time, equate these two expressions for the distance the car travels.

$$(95\text{ km/h})t = 1.30\text{ km} - (75\text{ km/h})t \;\rightarrow\; t = \frac{1.30\text{ km}}{170\text{ km/h}} = 7.65\times10^{-3}\text{ h} \approx \boxed{28\text{ s}}$$

The distance the car travels during this time is $d = (95\text{ km/h})(7.65\times10^{-3}\text{ h}) = \boxed{0.73\text{ km}}$.

17. The average acceleration is found from Eq. 2–4.

$$\bar{a} = \frac{\Delta v}{\Delta t} = \frac{95\text{ km/h} - 0\text{ km/h}}{4.3\text{ s}} = \frac{(95\text{ km/h})\left(\frac{1000\text{ m}}{1\text{ km}}\right)\left(\frac{1\text{ h}}{3600\text{ s}}\right)}{4.3\text{ s}} = \boxed{6.1\text{ m/s}^2}$$

20. (II) At highway speeds, a particular automobile is capable of an acceleration of about 1.8 m/s^2. At this rate, how long does it take to accelerate from 65 km/h to 120 km/h?

21. (II) A car moving in a straight line starts at $x = 0$ at $t = 0$. It passes the point $x = 25.0$ m with a speed of 11.0 m/s at $t = 3.00$ s. It passes the point $x = 385$ m with a speed of 45.0 m/s at $t = 20.0$ s. Find (*a*) the average velocity, and (*b*) the average acceleration, between $t = 3.00$ s and $t = 20.0$ s.

$$\Delta t = \frac{\Delta v}{\bar{a}} = \frac{120\text{ km/h} - 65\text{ km/h}}{1.8\text{ m/s}^2} = \frac{(55\text{ km/h})\left(\frac{1\text{ m/s}}{3.6\text{ km/h}}\right)}{1.8\text{ m/s}^2} = 8.488\text{ s} \approx \boxed{8.5\text{ s}}$$

21. (*a*) $$\bar{v} = \frac{\Delta x}{\Delta t} = \frac{385\text{ m} - 25\text{ m}}{20.0\text{ s} - 3.0\text{ s}} = \boxed{21.2\text{ m/s}}$$

(*b*) $$\bar{a} = \frac{\Delta v}{\Delta t} = \frac{45.0\text{ m/s} - 11.0\text{ m/s}}{20.0\text{ s} - 3.0\text{ s}} = \boxed{2.00\text{ m/s}^2}$$