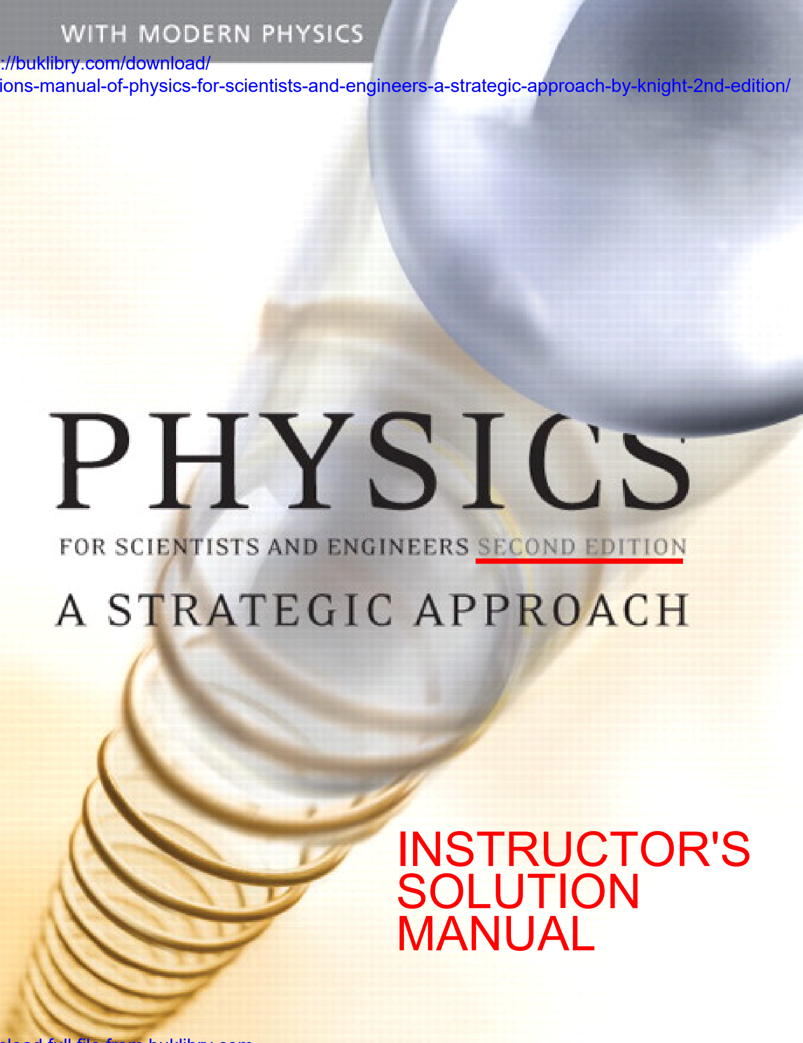
WITH MODERN PHYSICS



PHYSICS

FOR SCIENTISTS AND ENGINEERS SECOND EDITION

A STRATEGIC APPROACH

INSTRUCTOR'S SOLUTION MANUAL

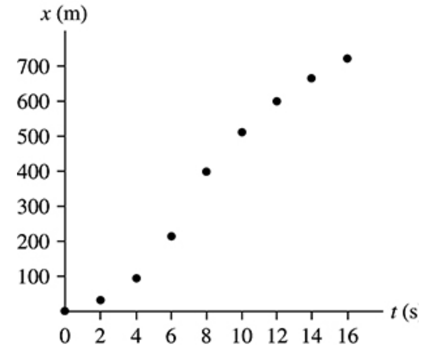
RANDALL D. KNIGHT

1.18. Solve:

(a)

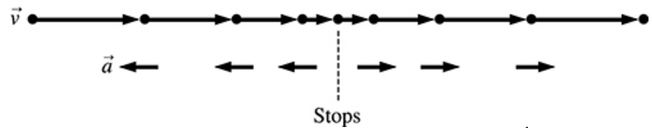
Dot	Time (s)	x (m)
1	0	0
2	2	30
3	4	95
4	6	215
5	8	400
6	10	510
7	12	600
8	14	670
9	16	720

(b)



1.49. Solve:

(a)



(b) Sue passes 3rd Street doing 40 mph, slows steadily to the stop sign at 4th Street, stops for 1 s, then speeds up and reaches her original speed as she passes 5th Street. If the blocks are 50 m long, how long does it take Sue to drive from 3rd Street to 5th Street?

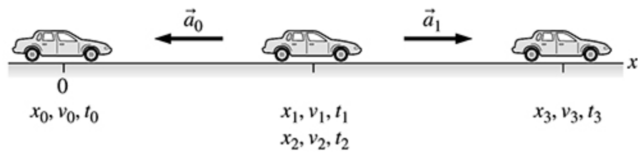
(c)

Known

$x_0 = 0 \quad t_0 = 0$
$v_0 = 40$ mph
$x_1 = x_2 = 50$ m
$v_1 = v_2 = 0$
$t_2 = t_1 + 1$ s
$x_3 = 100$ m $\quad v_3 = 40$ mph

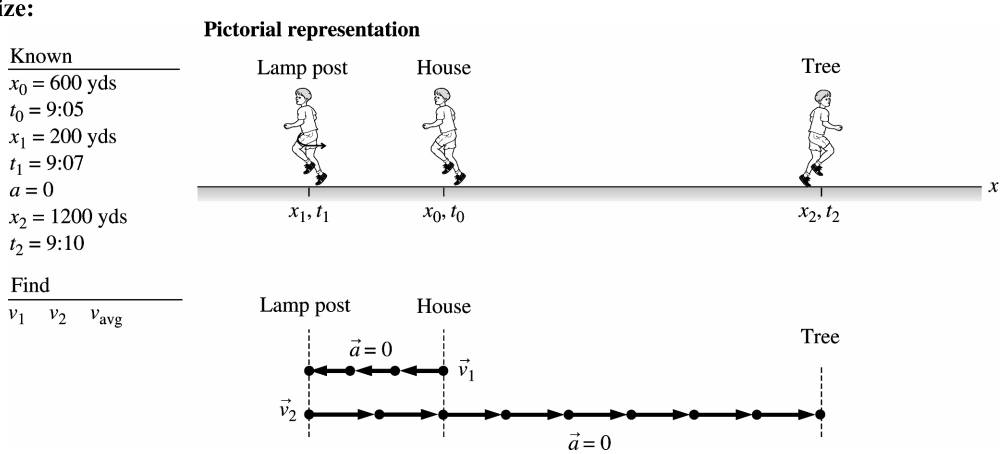
Find

t_3



2.2. Model: We will consider Larry to be a particle.

Visualize:



Solve: Since Larry's speed is constant, we can use the following equation to calculate the velocities:

$$v_s = \frac{s_f - s_i}{t_f - t_i}$$

(a) For the interval from the house to the lamppost:

$$v_1 = \frac{200 \text{ yd} - 600 \text{ yd}}{9{:}07 - 9{:}05} = -200 \text{ yd/min}$$

For the interval from the lamppost to the tree:

$$v_2 = \frac{1200 \text{ yd} - 200 \text{ yd}}{9{:}10 - 9{:}07} = +333 \text{ yd/min}$$

(b) For the average velocity for the entire run:

$$v_{avg} = \frac{1200 \text{ yd} - 600 \text{ yd}}{9{:}10 - 9{:}05} = +120 \text{ yd/min}$$

2.21. Solve: (a) The position $t = 2$ s is $x_{2\text{ s}} = [2(2)^2 - 2 + 1]$ m $= 7$ m.

(b) The velocity is the derivative $v = dx/dt$ and the velocity at $t = 2$ s is calculated as follows:

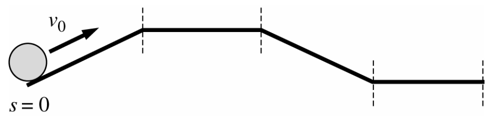
$$v = (4t^2 - 1)\text{ m/s} \Rightarrow v_{2\text{ s}} = [4(2) - 1]\text{ m/s} = 7\text{ m/s}$$

(c) The acceleration is the derivative $a = dv/dt$ and the acceleration at $t = 2$ s is calculated as follows:

$$a = (4)\text{ m/s}^2 \Rightarrow a_{2\text{ s}} = 4\text{ m/s}^2$$

2.40. Visualize: Please refer to Figure P2.40. There are four frictionless tracks.

Solve: For the first track, a_s is negative and constant and v_s is decreasing linearly. This is consistent with a ball rolling up a straight track but not so far that v_s goes to zero. For the second track, a_s is zero and v_s is constant but greater than zero. This is consistent with a ball rolling on a horizontal track. For the third track, a_s is positive and constant and v_s is increasing linearly. This is consistent with a ball rolling down a straight track. For the fourth track, a_s is zero and v_s is constant. This is again consistent with a ball rolling on a horizontal track. The a_s on the first track has the same absolute value as the a_s on the third track. This means the slope of the first track up is the same as the slope of the third track down.

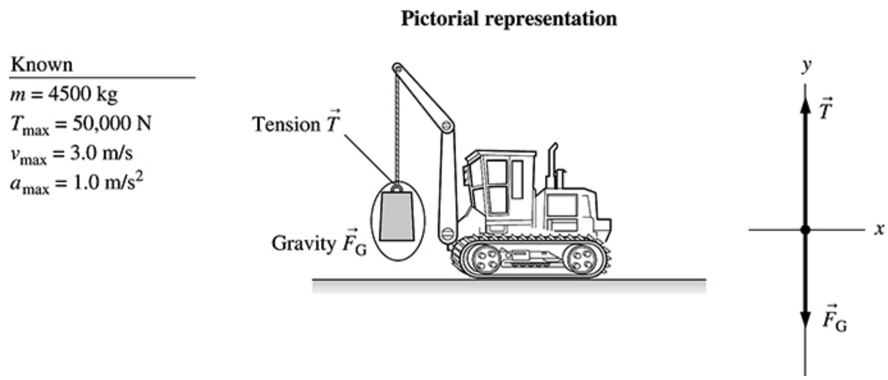


5.15. Visualize: Please refer to Figure EX5.15.

Solve: Newton's second law is $F = ma$. We can read a force and an acceleration from the graph, and hence find the mass. Choosing the force $F = 1\ \text{N}$ gives us $a = 4\ \text{m/s}^2$. Newton's second law yields $m = 0.25\ \text{kg}$.

6.56. Model: We will model the container as a particle of mass m. The steel cable of the crane will be assumed to have zero mass.

Visualize:



Solve: As long as the container is stationary or it is moving with a constant speed (zero acceleration), the net force on the container is zero. In these cases, the tension in the cable is equal to the gravitational force on the container:

$$T = mg = 44{,}000 \text{ N}$$

The cable should safely lift the load. More tension is required to accelerate the load. Newton's second law is

$$(F_{net})_y = \Sigma F_y = (F_G)_y + (T)_y = -mg + T = ma_y$$

The crane's maximum acceleration is $a_{max} = 1.0 \text{ m/s}^2$. So the maximum cable tension is

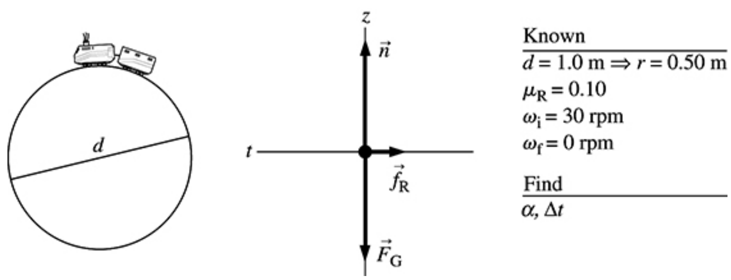
$$T_{max} = mg + ma_{max} = 48{,}600 \text{ N}$$

This is less than the cable's rating, so the cable must have been defective.

8.19. Model: The train is a particle undergoing nonuniform circular motion.

Visualize:

Pictorial representation



Solve: **(a)** Newton's second law in the vertical direction is

$$(F_{net})_y = n - F_G = 0$$

from which $n = mg$. The rolling friction is $f_R = \mu_R n = \mu_R mg$. This force provides the tangential acceleration

$$a_t = -\frac{f_R}{m} = -\mu_R g$$

The angular acceleration is

$$\alpha = \frac{a_t}{r} = \frac{-\mu_R g}{r} = \frac{-(0.10)(9.8 \text{ m/s}^2)}{0.50 \text{ m}} = -1.96 \text{ rad/s}^2$$

(b) The initial angular velocity is $30\left(\frac{\text{rev}}{\text{min}}\right)\left(\frac{1 \text{ min}}{60 \text{ sec}}\right)\left(\frac{2\pi \text{ rad}}{\text{rev}}\right) = 3.14$ rad/s. The time to come to a stop due to the rolling friction is

$$\Delta t = \frac{\omega_f - \omega_i}{\alpha} = \frac{0 - 3.14 \text{ rad/s}}{-1.96 \text{ rad/s}^2} = 1.60 \text{ s}$$

Assess: The original angular speed of π rad/s means the train goes around the track one time every 2 seconds, so a stopping time of less than 2 s is reasonable.

12.17. Model: The door is a slab of uniform density.

Solve: **(a)** The hinges are at the edge of the door, so from Table 12.2,

$$I = \frac{1}{3}(25\text{ kg})(0.91\text{ m})^2 = 6.9\text{ kg m}^2$$

(b) The distance from the axis through the center of mass along the height of the door is $d = \left(\frac{0.91\text{ m}}{2} - 0.15\text{ m}\right) = 0.305\text{ m}.$ Using the parallel–axis theorem,

$$I = I_{\text{cm}} + Md^2 = \frac{1}{12}(25\text{ kg})(0.91\text{ m})^2 + (25\text{ kg})(0.305\text{ cm})^2 = 4.1\text{ kg m}^2$$

Assess: The moment of inertia is less for a parallel axis through a point closer to the center of mass.

14.43. Model: The transducer undergoes simple harmonic motion.

Solve: Newton's second law for the transducer is

$$F_{\text{restoring}} = ma_{\text{max}} \Rightarrow 40{,}000 \text{ N} = \left(0.10\times10^{-3} \text{ kg}\right)a_{\text{max}} \Rightarrow a_{\text{max}} = 4.0\times10^{8} \text{ m/s}^2$$

Because $a_{\text{max}} = \omega^2 A$,

$$A = \frac{a_{\text{max}}}{\omega^2} = \frac{4.0\times10^{8} \text{ m/s}^2}{\left[2\pi\left(1.0\times10^{6} \text{ Hz}\right)\right]^2} = 1.01\times10^{-5} \text{ m} = 10.1 \text{ }\mu\text{m}$$

(b) The maximum velocity is

$$v_{\text{max}} = \omega A = 2\pi\left(1.0\times10^{6} \text{ Hz}\right)\left(1.01\times10^{-5} \text{ m}\right) = 64 \text{ m/s}$$

15.63. Model: Treat the air as an ideal fluid obeying Bernoulli's equation.
Solve: (a) The pressure above the roof is lower due to the higher velocity of the air.
(b) Bernoulli's equation, with $y_{\text{inside}} \approx y_{\text{outside}}$, is

$$p_{\text{inside}} = p_{\text{outside}} + \tfrac{1}{2}\rho_{\text{air}}v^2 \Rightarrow \Delta p = \frac{1}{2}\rho_{\text{air}}v^2 = \frac{1}{2}\left(1.28 \text{ kg/m}^3\right)\left(\frac{130\times 1000 \text{ m}}{3600 \text{ s}}\right)^2 = 835 \text{ Pa}$$

The pressure difference is 0.83 kPa
(c) The force on the roof is $(\Delta p)A = (835 \text{ Pa})(6.0 \text{ m}\times 15.0 \text{ m}) = 7.5\times 10^4$ N. The roof will blow up, because pressure inside the house is greater than pressure on the top of the roof.

17.12. Model: The spinning paddle wheel does work and changes the water's thermal energy and its temperature.

Solve: **(a)** The temperature change is $\Delta T = T_f - T_i = 25°C - 21°C = 4$ K. The mass of the water is

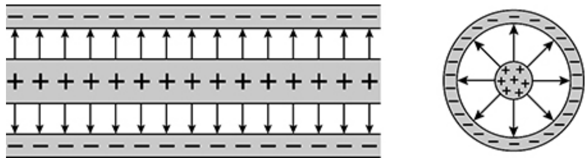
$$M = (200 \times 10^{-6} \text{ m}^3)(1000 \text{ kg/m}^3) = 0.20 \text{ kg}$$

The work done is

$$W = \Delta E_{th} = Mc_{water}\Delta T = (0.20 \text{ kg})(4190 \text{ J/kg K})(4 \text{ K}) = 3350 \text{ J} \approx 3400 \text{ J}$$

(b) $Q = 0$. No energy is transferred between the system and the environment because of a difference in temperature.

28.1. Visualize:



As discussed in Section 28.1, the symmetry of the electric field must match the symmetry of the charge distribution. In particular, the electric field of a cylindrically symmetric charge distribution cannot have a component parallel to the cylinder axis. Also, the electric field of a cylindrically symmetric charge distribution cannot have a component tangent to the circular cross section. The only shape for the electric field that matches the symmetry of the charge distribution with respect to (i) translation parallel to the cylinder axis, (ii) rotation by an angle about the cylinder axis, and (iii) reflections in any plane containing or perpendicular to the cylinder axis is the one shown in the figure.

34.27. Visualize: Please refer to Figure P34.27. To calculate the flux we need to consider the orientation of the normal of the surface relative to the magnetic field direction. We will consider the flux through the surface in the two parts corresponding to the two different directions of the surface normals.

Solve: The flux is

$$\Phi = \Phi_{\text{top}} + \Phi_{\text{left}} = \vec{A}_{\text{top}} \cdot \vec{B} + \vec{A}_{\text{left}} \cdot \vec{B} = A_{\text{top}} B \cos 45° + A_{\text{left}} B \cos 45°$$
$$= 2 \times (0.050 \text{ m} \times 0.10 \text{ m})(0.050 \text{ T}) \cos 45° = 3.5 \times 10^{-4} \text{ Wb}$$

42.5. Solve: A 6*f* state for a hydrogen atom corresponds to $n = 6$ and $l = 3$. Using Equation 42.2,

$$E_6 = \frac{-13.6 \text{ eV}}{6^2} = -0.378 \text{ eV}$$

The magnitude of the angular momentum is $L = \sqrt{l(l+1)}\hbar = \sqrt{3(3+1)}\hbar = \sqrt{12}\hbar$.