STUDENT SOLUTIONS MANUAL

PHYSICS

FOR SCIENTISTS AND ENGINEERS SECOND EDITION

A STRATEGIC APPROACH

RANDALL D. KNIGHT

CHAPTERS 1–19

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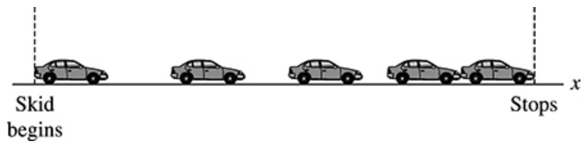
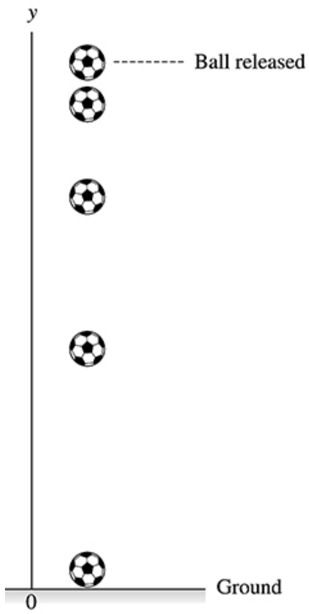
LARRY SMITH • SCOTT NUTTER

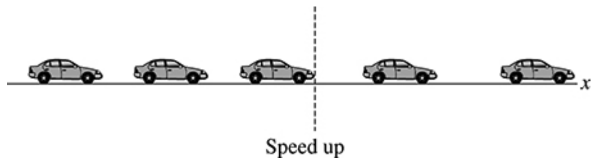
1.1. Solve:



1.2. **Solve:**



1.3. Solve:



1.4. Solve: (a) The basic idea of the particle model is that we will treat an object *as if* all its mass is concentrated into a single point. The size and shape of the object will not be considered. This is a reasonable approximation of reality if (i) the distance traveled by the object is large in comparison to the size of the object, and (ii) rotations and internal motions are not significant features of the object's motion. The particle model is important in that it allows us to *simplify* a problem. Complete reality—which would have to include the motion of every single atom in the object—is too complicated to analyze. By treating an object as a particle, we can focus on the most important aspects of its motion while neglecting minor and unobservable details.

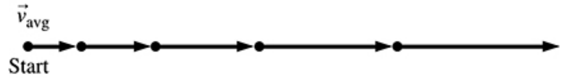
(b) The particle model is valid for understanding the motion of a satellite or a car traveling a large distance.

(c) The particle model is not valid for understanding how a car engine operates, how a person walks, how a bird flies, or how water flows through a pipe.

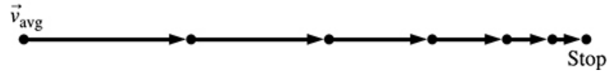
1.5. Solve: (a) An operational definition defines a concept or an idea in terms of a *procedure*, or a set of operations, that is used to identify or measure the concept.

(b) The *displacement* $\Delta\vec{r}$ of an object is a vector found by drawing an arrow from the object's initial location to its final location. Mathematically, $\Delta\vec{r} = \vec{r}_{\mathrm{f}} - \vec{r}_{\mathrm{i}}$. The *average velocity* $\vec{v}$ of an object is a vector that points in the same direction as the displacement $\Delta\vec{r}$ and has length, or magnitude, $\Delta\vec{r}/\Delta t$, where $\Delta t = t_{\mathrm{f}} - t_{\mathrm{i}}$ is the time interval during which the object moves from its initial location to its final location.

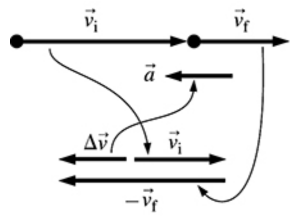
1.6. Solve: The player starts from rest and moves faster and faster (accelerates).



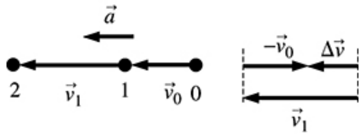
1.7. **Solve:** The particle starts with an initial velocity but as it slides it moves slower and slower till coming to rest. This is a case of negative acceleration because it is an acceleration opposite to the positive direction of motion.



1.8. Solve: The acceleration of an object is a vector formed by finding the ratio of $\Delta\vec{v}$, the change in the object's velocity, to Δt, the time in which the change occurs. The acceleration vector $\vec{a}$ points in the direction of $\Delta\vec{v}$, which is found by vector subtraction.

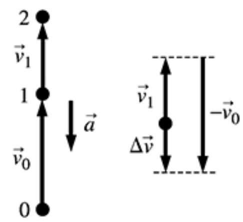


1.9. Solve: (a) Acceleration is found by the method of Tactics Box 1.3. Let $\vec{v}_0$ be the velocity vector between points 0 and 1 and $\vec{v}_1$ be the velocity vector between points 1 and 2.



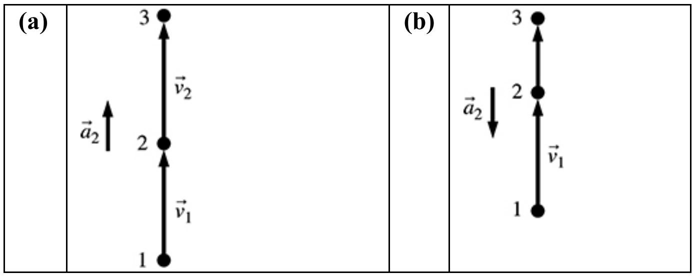
(b) Speed v_1 is greater than speed v_0 because more distance is covered in the same interval of time.

1.10. Solve: (a) Acceleration is found by the method of Tactics Box 1.3. Let $\vec{v}_0$ be the velocity vector between points 0 and 1 and $\vec{v}_1$ be the velocity vector between points 1 and 2.



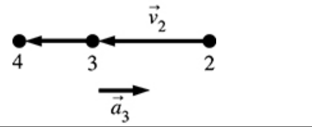
(b) Speed v_1 is greater than speed v_0 because more distance is covered in the same interval of time.

1.11. **Solve:**

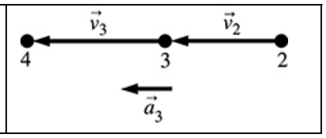


1.12. **Solve:**

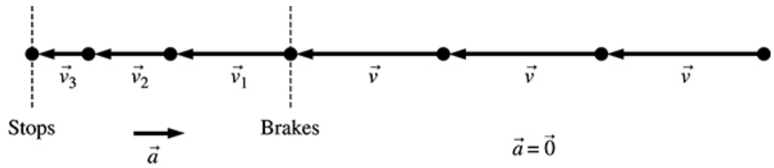
(a)



(b)

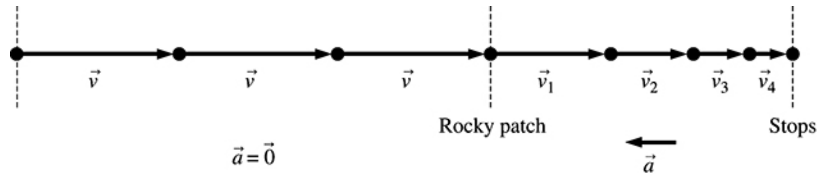


1.13. **Model:** Represent the car as a particle.



Visualize: The dots are equally spaced until brakes are applied to the car. Equidistant dots indicate constant average speed. On braking, the dots get closer as the average speed decreases.

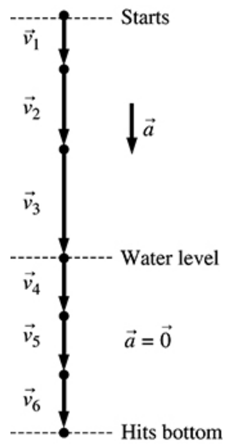
1.14. **Model:** Represent the (child + sled) system as a particle.



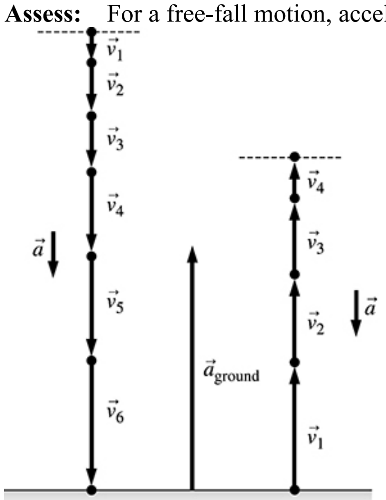
Visualize: The dots in the figure are equally spaced until the sled encounters a rocky patch. Equidistant dots indicate constant average speed. On encountering a rocky patch, the average speed decreases and the sled comes to a stop. This part of the motion is indicated by a separation between the dots that becomes smaller and smaller.

1.15. Model: Represent the tile as a particle.

Visualize: The tile falls from the roof with an acceleration equal to $a = g = 9.8\ \text{m/s}^2$. Starting from rest, its velocity increases until the tile hits the water surface. This part of the motion is represented by dots with increasing separation, indicating increasing average velocity. After the tile enters the water, it settles to the bottom at roughly constant speed.

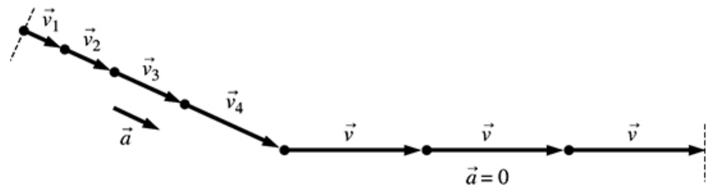


1.16. **Model:** Represent the tennis ball as a particle.
Visualize: The particle falls freely for the three stories under the acceleration of gravity. It strikes the ground and very quickly decelerates to zero (while decompresses) and finally travels upward with negative acceleration under gravity to zero velocity at a height of two stories. The downward and upward motions of the ball are shown in the figure. The increasing length between the dots during downward motion indicates increasing average velocity or downward acceleration. On the other hand, the decreasing length between the dots during upward motion indicates acceleration in a direction opposite to its motion; that is, in the downward direction.
Assess: For a free-fall motion, acceleration due to gravity is always vertically downward.



1.17. Model: Represent the toy car as a particle.

Visualize: As the toy car rolls down the ramp, its average speed increases. This is indicated by the increasing length of the velocity arrows. That is, motion down the ramp is under an acceleration $\vec{a}$. At the bottom of the ramp, the toy car continues with the speed obtained with no change in velocity.

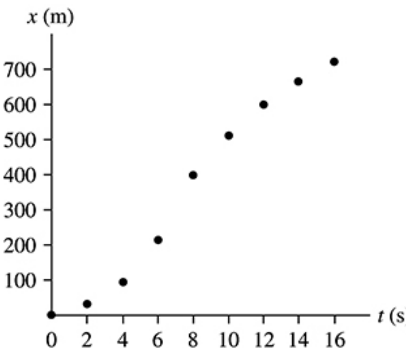


1.18. Solve:

(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

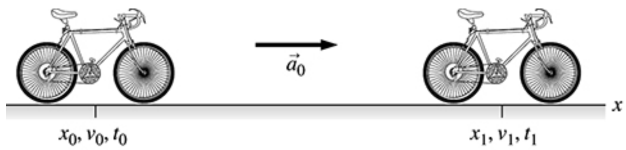
(b)



1.19. **Solve:** A forgetful physics professor goes for a walk on a straight country road. Walking at a constant speed, he covers a distance of 300 m in 300 s. He then stops and watches the sunset for 100 s. Finding that it was getting dark, he walks faster back to his house covering the same distance in 200 s.

1.20. Solve: Forty miles into a car trip north from his home in El Dorado, an absent-minded English professor stopped at a rest area one Saturday. After staying there for one hour, he headed back home thinking that he was supposed to go on this trip on Sunday. Absent-mindedly he missed his exit and stopped after one hour of driving at another rest area 20 miles south of El Dorado. After waiting there for one hour, he drove back very slowly, confused and tired as he was, and reached El Dorado in two hours.

1.21. **Visualize:** The bicycle is moving with an acceleration of 1.5 m/s^2. Thus, the velocity will increase by 1.5 m/s each second of motion.



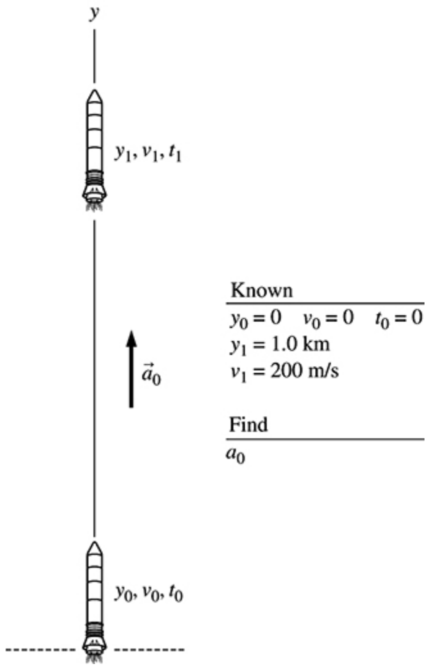
Known

$v_0 = 0 \quad t_0 = 0 \quad x_0 = 0$
$a_0 = 1.5$ m/s^2
$v_1 = 7.5$ m/s

Find

x_1

1.22. Visualize: The particle moves upward with a constant acceleration $\vec{a}$. The final velocity is 200 m/s and is reached at a height of 1000 m.



1.23. Solve: (a) $9.12\ \mu\text{s} = (9.12\ \mu\text{s})\left(\dfrac{10^{-6}\text{s}}{1\ \mu\text{s}}\right) = 9.12\times10^{-6}\ \text{s}$

(b) $3.42\ \text{km} = (3.42\ \text{km})\left(\dfrac{10^{3}\ \text{m}}{1\ \text{km}}\right) = 3.42\times10^{3}\ \text{m}$

(c) $44\ \text{cm/ms} = 44\left(\dfrac{\text{cm}}{\text{ms}}\right)\left(\dfrac{10^{-2}\ \text{m}}{1\ \text{cm}}\right)\left(\dfrac{1\ \text{ms}}{10^{-3}\ \text{s}}\right) = 4.4\times10^{2}\ \text{m/s}$

(d) $80\ \text{km/hour} = 80\left(\dfrac{\text{km}}{\text{hour}}\right)\left(\dfrac{10^{3}\ \text{m}}{1\ \text{km}}\right)\left(\dfrac{1\ \text{hour}}{3600\ \text{s}}\right) = 22\ \text{m/s}$

1.24. Solve: (a) $8.0\ \text{inches} = 8.0\ (\text{inch})\left(\dfrac{2.54\ \text{cm}}{1\ \text{inch}}\right)\left(\dfrac{10^{-2}\ \text{m}}{1\ \text{cm}}\right) = 0.20\ \text{m}$

(b) $66\ \text{feet/s} = 66\left(\dfrac{\text{feet}}{\text{s}}\right)\left(\dfrac{12\ \text{inch}}{1\ \text{foot}}\right)\left(\dfrac{1\ \text{m}}{39.37\ \text{inch}}\right) = 20\ \text{m/s}$

(c) $60\ \text{mph} = 60\left(\dfrac{\text{miles}}{\text{hour}}\right)\left(\dfrac{1.609\ \text{km}}{1\ \text{mile}}\right)\left(\dfrac{10^3\ \text{m}}{1\ \text{km}}\right)\left(\dfrac{1\ \text{hour}}{3600\ \text{s}}\right) = 27\ \text{m/s}$

(d) $14\ \text{square inches} = 14\ (\text{inches})^2\left(\dfrac{1\ \text{m}}{39.37\ \text{inches}}\right)^2 = 9.0\times10^{-3}\ \text{square meter}$

1.25. Solve: (a) $1\text{ hour} = 1(\text{hour})\left(\dfrac{3600\text{ s}}{1\text{ hour}}\right) = 3600\text{ s} = 3.60\times10^{3}\text{ s}$

(b) $1\text{ day} = 1\ (\text{day})\left(\dfrac{24\text{ hours}}{1\text{ day}}\right)\left(\dfrac{3600\text{ s}}{1\text{ hour}}\right) = 8.64\times10^{4}\text{ s}$

(c) $1\text{ year} = 1\ (\text{year})\left(\dfrac{365.25\text{ days}}{1\text{ year}}\right)\left(\dfrac{8.64\times10^{4}\text{ s}}{1\text{ day}}\right) = 3.16\times10^{7}\text{ s}$

(d) $32\text{ ft/s}^2 = 32\left(\dfrac{\text{ft}}{\text{s}^2}\right)\left(\dfrac{12\text{ inch}}{1\text{ ft}}\right)\left(\dfrac{1\text{ m}}{39.37\text{ inch}}\right) = 9.75\text{ m/s}^2$

1.26. Solve: (a) $20\text{ ft} = 20(\text{ft})\left(\dfrac{1\text{ m}}{3\text{ ft}}\right) = 7.0\text{ m}$

(b) $60\text{ miles} = 60(\text{miles})\left(\dfrac{1\text{ km}}{0.6\text{ miles}}\right)\left(\dfrac{1000\text{ m}}{1\text{ km}}\right) = 1.0\times10^{5}\text{ m}$

(c) $60\text{ mph} = 60(\text{mph})\left(\dfrac{1\text{ m/s}}{2\text{ mph}}\right) = 30\text{ m/s}$

(d) $8\text{ in} = 8(\text{in})\left(\dfrac{1\text{ cm}}{1/2\text{ in}}\right)\left(\dfrac{10^{-2}\text{ m}}{1\text{ cm}}\right) = 0.16\text{ m}$

1.27. Solve:

(a) $(30\text{ cm})\left(\dfrac{4\text{ in}}{10\text{ cm}}\right)=12\text{ in}$

(b) $(25\text{ m/s})\left(\dfrac{2\text{ mph}}{1\text{ m/s}}\right)=50\text{ mph}$

(c) $(5\text{ km})\left(\dfrac{0.6\text{ mi}}{1\text{ km}}\right)=3\text{ mi}$

(d) $\left(\dfrac{1}{2}\text{ cm}\right)\left(\dfrac{\frac{1}{2}\text{ in}}{1\text{ cm}}\right)=\dfrac{1}{4}\text{ in}$

1.28. **Solve:** **(a)** $33.3 \times 25.4 = 846$

(b) $33.3 - 25.4 = 7.9$

(c) $\sqrt{33.3} = 5.77$

(d) $333.3 \div 25.4 = 13.1$

1.29. Solve: (a) $(33.3)^2 = 1.109 \times 10^3$. For numbers starting with "1" an extra digit is kept.

(b) $33.3 \times 45.1 = 1.50 \times 10^3$

Scientific notation is an easy way to establish significance.

(c) $\sqrt{22.2} - 1.2 = 3.5$

(d) $1/44.4 = 0.0225$

1.30. Solve: The length of a typical car is 15 ft. Or

$$15(\text{ft})\left(\frac{12\text{ inch}}{1\text{ ft}}\right)\left(\frac{1\text{ m}}{39.37\text{ inch}}\right)=4.6\text{ m}$$

This length of 15 ft is approximately two-and-a-half times my height.

1.31. Solve: The height of a telephone pole is estimated to be around 50 ft or 15 m. This height is approximately
8 times my height.

1.32. Solve: I typically take 15 minutes in my car to cover a distance of approximately 6 miles from home to campus. My average speed is

$$\frac{6\text{ miles}}{15\text{ min}}\left(\frac{60\text{ min}}{1\text{ hour}}\right) = 24\text{ mph} = 24(\text{mph})\left(\frac{0.447\text{ m/s}}{1\text{ mph}}\right) = 11\text{ m/s}$$

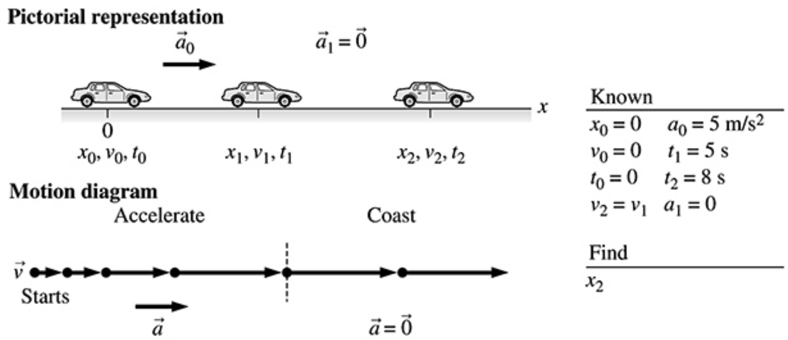
1.33. Solve: My barber trims about an inch of hair when I visit him every month for a haircut. The rate of hair growth is

$$\frac{1(\text{inch})}{(\text{month})}\left(\frac{2.54\text{ cm}}{1\text{ inch}}\right)\left(\frac{10^{-2}\text{ m}}{1\text{ cm}}\right)\left(\frac{1\text{ month}}{30\text{ days}}\right)\left(\frac{1\text{ day}}{24\text{ h}}\right)\left(\frac{1\text{ h}}{3600\text{ s}}\right)=9.8\times10^{-9}\text{ m/s}$$

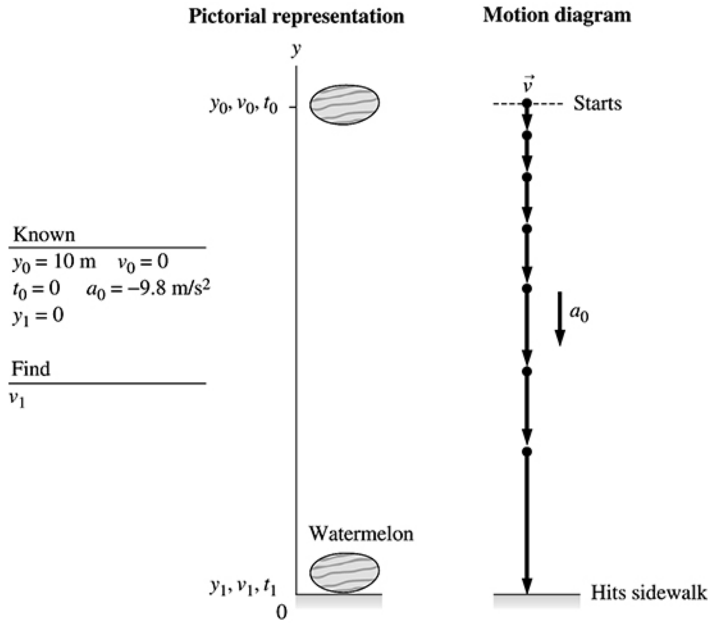
$$=9.8\times10^{-9}\left(\frac{\text{m}}{\text{s}}\right)\left(\frac{10^{6}\ \mu\text{m}}{1\text{ m}}\right)\left(\frac{3600\text{ s}}{1\text{ h}}\right)=35\ \mu\text{m/h}$$

1.34. Model: Represent the Porsche as a particle for the motion diagram.

Visualize:

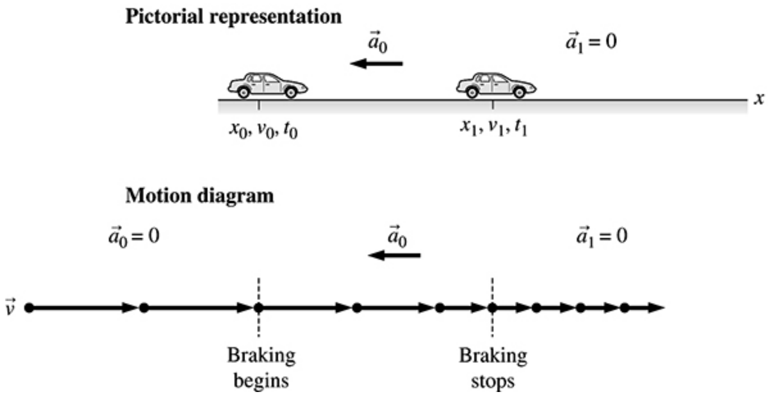


1.35. Model: Represent the watermelon as a particle for the motion diagram.
Visualize:



1.36. Model: Represent (Sam + car) as a particle for the motion diagram.

Visualize:



Known

$x_0 = 0 \quad v_0 = 60$ mph $\quad t_0 = 0$

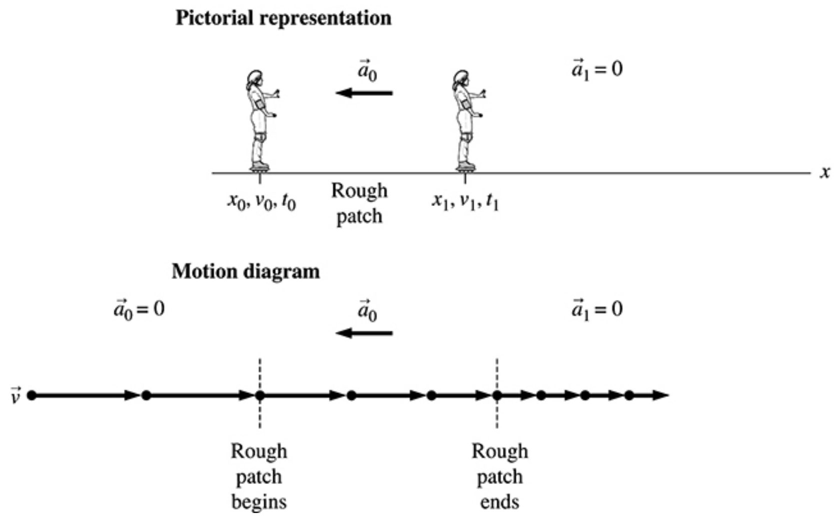
$v_1 = 30$ mph $\quad t_1 = 3$ s

Find

x_1

1.37. Model: Represent the speed skater as a particle for the motion diagram.

Visualize:



Known

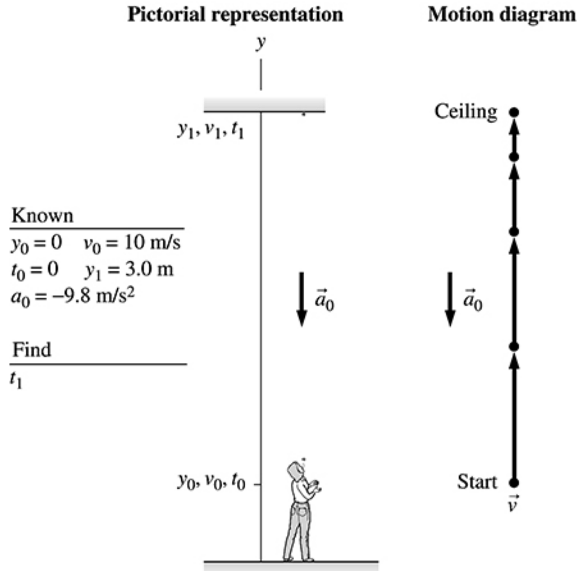
$x_0 = 0 \quad v_0 = 8.0 \text{ m/s} \quad t_0 = 0$

$x_1 = 5.0 \text{ m} \quad v_1 = 6.0 \text{ m/s}$

Find

a_0

1.38. **Model:** Represent the wad as a particle for the motion diagram.
Visualize:



1.39. Model: Represent the ball as a particle for the motion diagram.

Visualize: