Unit: N
Chapter: N1
Problem Number: N1B.6
Return to User Page

N1B.6 **(a)** Using the product rule: $c(at^2 + b) + ct(2at) = 3cat^2 + cb$. One gets the same result by multiplying the ct and the $(at^2 + b)$ and then taking the derivative.

(b) Using the chain rule: $-2a\,(at+b)^{-3}$.

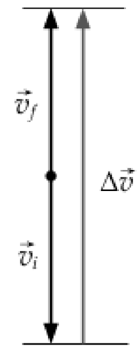
(c) Using the product rule: $(3at^2)/t - (at^3+b)/t^2 = -at + 3at - b/t^2 = 2at - b/t^2$. One gets the same result by multiplying the functions and then taking the derivative.

Unit: N
Chapter: N1
Problem Number: N1B.9
Return to User Page

N1B.9 Since it comes back exactly to where it started, its displacement $\Delta\vec{r}$ (which is d*efined* to be its initial position vector minus its final position vector) during this time period is *zero*. This means that its average velocity during this time interval (which is defined to be $\vec{v} \equiv \Delta\vec{r}\,/\,\Delta t$) is also zero, in spite of the fact that the object has indeed moved around the circle. This strange result is a consequence of the definitions we are using! (You can think about this result this way: remember that average velocity averages the direction as well as the speed of the object's motion. The average direction of motion for something moving in a circle is no direction: since the object moves in each possible direction in the plane for an equal amount of time, the directions all cancel out.)

Unit: N
Chapter: N1
Problem Number: N1B.11
Return to User Page

N1B.11 The person's initial velocity is $\vec{v}_i = 5.0$ m/s downward and final velocity is $\vec{v}_f = 5.0$ m/s upward. As the arrow construction below shows, this means that the person's change in velocity is $\Delta\vec{v} = 10$ m/s upward. The person's average acceleration is therefore $\vec{a} \equiv \Delta\vec{v}\,/\,\Delta t = (10\text{ m/s})/(1.8\text{ s}) = 5.6\text{ m/s}^2$ upward.



Unit: N
Chapter: N1
Problem Number: N1B.12

Return to User Page

N1B.12 Equation N1.14 tells us that

$$\vec{a} \equiv \frac{\Delta\vec{v}}{\Delta t} \quad \Rightarrow \quad |\vec{a}| = \frac{|\Delta\vec{v}|}{\Delta t} \quad \Rightarrow \quad \Delta t = \frac{|\Delta\vec{v}|}{|\vec{a}|} \tag{1}$$

We are told that the spaceship starts from rest ($\vec{v}_i = 0$) and needs to reach a final speed of $|\vec{v}_f| = \frac{1}{2}c$ while accelerating with an average acceleration of magnitude $|\vec{a}| = 15\ \text{m/s}^2$. When $\vec{v}_i = 0$, then $\Delta\vec{v} = \vec{v}_f$, so

$$\Delta t = \frac{|\vec{v}_f|}{|\vec{a}|} = \frac{\frac{1}{2}(3.0\times 10^8\ \text{m/s})}{15\ \text{m/s}^2} = 1.0\times 10^7\ \text{s}\left(\frac{1\ \text{h}}{3600\ \text{s}}\right)\left(\frac{1\ \text{day}}{24\ \text{h}}\right) \approx 120\ \text{days}. \tag{2}$$

Unit: N
Chapter: N1
Problem Number: N1M.2

Return to User Page

N1M.2 Let's assume that walking speed is

$$|\vec{v}_f| = 3.0\,\frac{\cancel{\text{mi}}}{\cancel{\text{h}}}\left(\frac{1\text{ m/s}}{2.2\,\cancel{\text{mi}}/\cancel{\text{h}}}\right) = 1.4\,\frac{\text{m}}{\text{s}} \tag{1}$$

To accelerate the car to this speed from $\vec{v}_i = 0$ in $\Delta t = 4$ s requires a horizontal average acceleration of

$$|\vec{a}| = \frac{|\Delta\vec{v}|}{\Delta t} = \frac{|\vec{v}_f - \vec{v}_i|}{\Delta t} = \frac{|\vec{v}_f|}{\Delta t} = \frac{1.4\text{ m/s}}{4\text{ s}} = 0.35\,\frac{\text{m}}{\text{s}^2} \tag{2}$$

Newton's second law then requires that a car of mass $M = 1500$ kg receive an average horizontal push of

$$|\vec{F}_{\text{ext}}| = M|\vec{a}| = 1500\,\cancel{\text{kg}}\left(0.35\,\frac{\cancel{\text{m}}}{\cancel{\text{s}^2}}\right)\left(\frac{1\text{ N}}{1\,\cancel{\text{kg}}\cdot\cancel{\text{m/s}^2}}\right) = 525\text{ N} \tag{3}$$

to have this average acceleration. (The vertical forces of gravity and the normal force exerted by the road cancel each other out, so the horizontal force is the same as the total vector sum of the forces on the car in this case.) Now, lifting a barbell of mass m requires exerting a force on it equal to its weight $|\vec{F}_g| = m|\vec{g}|$. For this to be equal to $|\vec{F}_{\text{ext}}|$, we must have

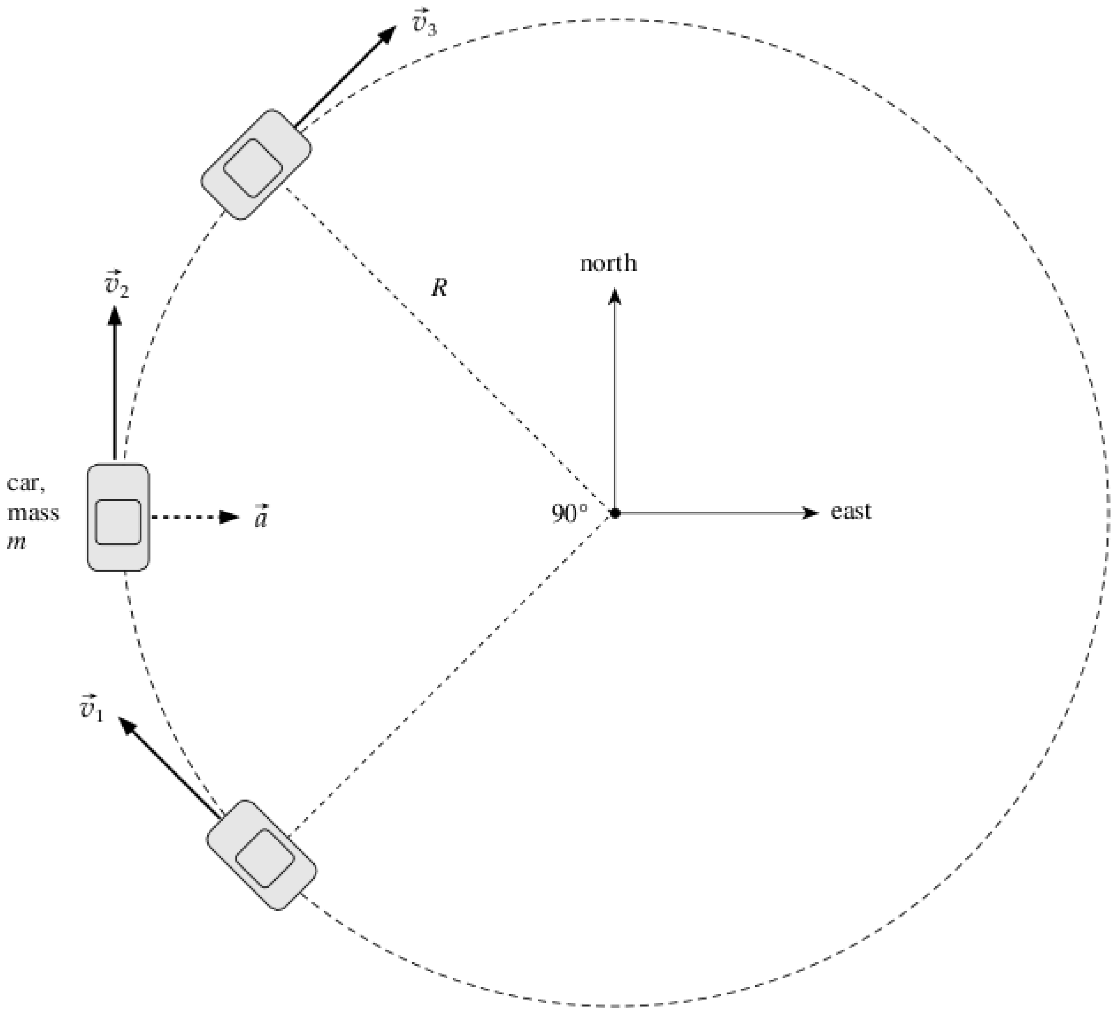
$$m|\vec{g}| = |\vec{F}_{\text{ext}}| \quad\Rightarrow\quad m = \frac{|\vec{F}_{\text{ext}}|}{|\vec{g}|} = \frac{525\,\cancel{\text{N}}}{9.8\,\cancel{\text{m/s}^2}}\left(\frac{1\text{ kg}\cdot\cancel{\text{m/s}^2}}{1\,\cancel{\text{N}}}\right) = 54\text{ kg} \tag{4}$$

This is a lot of mass to lift (such a barbell would weigh about 120 lbs). So pushing a car this hard will not be easy.

Unit: N
Chapter: N1
Problem Number: N1M.8

Return to User Page

N1M.8 Here is a picture of the situation:



The car's speed is constant, so $|\vec{v}_1| = |\vec{v}_2| = |\vec{v}_3| \equiv |\vec{v}| = 20$ m/s. If we assume that the corner is circular with some radius R, then since the car must turn by 90° to go from facing northwest to northeast, it must travel one quarter of the circle's circumference $2\pi R$ in time $T = 10$ s. Therefore, the circle's radius must be such that

$$|\vec{v}|T = \frac{2\pi R}{4} = \frac{\pi R}{2} \quad \Rightarrow \quad R = \frac{2|\vec{v}|T}{\pi} = \frac{2(20\text{ m/s})(10\text{ s})}{\pi} = 127\text{ m} \tag{1}$$

The acceleration of an object in circular motion is toward the center of the circle with a magnitude of $|\vec{a}| = |\vec{v}|^2/R$, which in this case will be

$$|\vec{a}| = \frac{|\vec{v}|^2}{R} = \frac{(20\text{ m/s})^2}{127\text{ m}} = 3.14\ \frac{\text{m}}{\text{s}^2} \tag{2}$$

By Newton's second law $\vec{F}_{net} = m\vec{a}$, then, the magnitude of the net force acting on the car will be

$$|\vec{F}_{net}| = m|\vec{a}| = (1500\text{ kg})\left(3.14\ \frac{\text{m}}{\text{s}^2}\right)\left(\frac{1\text{ N}}{1\text{ kg}\cdot\text{m/s}^2}\right) = 4700\text{ N} \tag{3}$$

The direction of the force will be the same as the direction of the car's acceleration, which at the instant in question is due east.