SLE123 Physics for the Life Sciences

1.3 Acceleration: Rate of Change of Velocity - ANSWERS

1. Yes. The acceleration vector will point west when the jet is slowing down while traveling east. The acceleration vector will always point in the direction opposite the velocity vector in straight-line motion if the object is slowing down. Feeling good about this concept requires letting go of the common every day (mis)usage where velocity and acceleration are sometimes treated like synonyms. Physics definitions of these terms are more precise and when discussing physics, we need to use them precisely.

2. We are asked to find the largest of four accelerations, so we compute all four:

$$a = \frac{\Delta v}{\Delta t}$$

A. $$a = \frac{4\, m/s}{2.0 s} = 2.0\, m/s^2$$

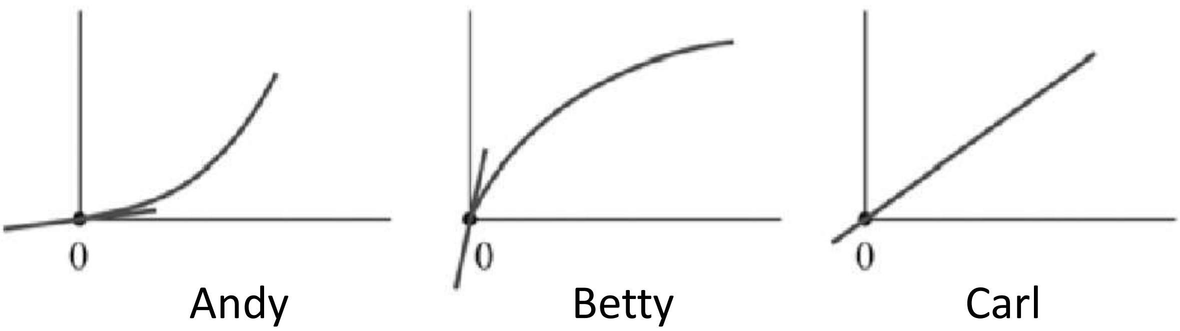
B. $$a = \frac{6.0\, m/s}{4.0 s} = 1.5\, m/s^2$$

C. $$a = \frac{28\, m/s}{9.0 s} = 3.1\, m/s^2$$

D. $$a = \frac{3.0\, m/s}{1.0 s} = 3.0\, m/s^2$$

The largest of these is C, so the correct choice is C.

3. The slope of the tangent to the velocity-versus-time graph gives the acceleration of each car. At time t = 0 s the slope of the tangent to Andy's velocity-versus-time graph is very small. The slope of the tangent to the graph at the same time for Carl is larger. However, the slope of the tangent in Betty's case is the largest of the three. So, Betty had the greatest acceleration at t = 0 s.



4. This can be solved with simple ratios. Since:

$$a = \frac{\Delta v}{\Delta t}$$

And the acceleration stays the same, it would take twice as long to change the velocity twice as much. The answer is B.

5. This can be solved with simple ratios. Since:

$$a = \frac{\Delta v}{\Delta t}$$

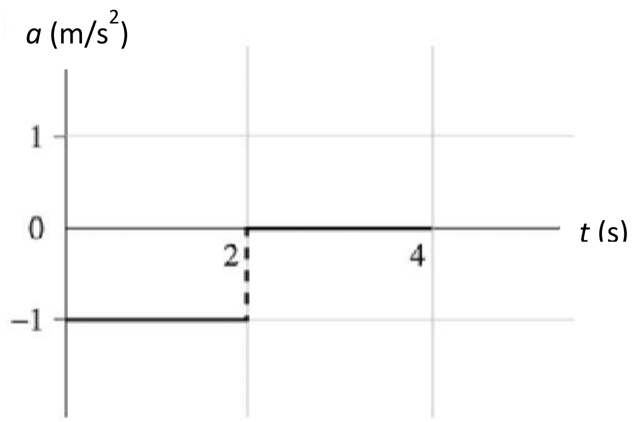
If the acceleration is doubled then the car can change velocity by twice as much in the same amount of time. The answer is A.

6. A predator capable of running at a great speed while not being capable of large accelerations could overtake slower prey that were capable of large accelerations, given enough time. However, it may not be as effective as surprising and grabbing prey that are capable of higher acceleration. For example, prey could escape if the safety of a burrow were nearby. If a predator were capable of larger accelerations than its prey, while being slower in speed than the prey, it would have a greater chance of surprising and grabbing prey, quickly, though prey might outrun it if given enough warning.

7. The graph in the question shows distinct slopes in the time intervals: 0 – 2 s and 2 s – 4 s. We can thus obtain the acceleration values from this graph using:

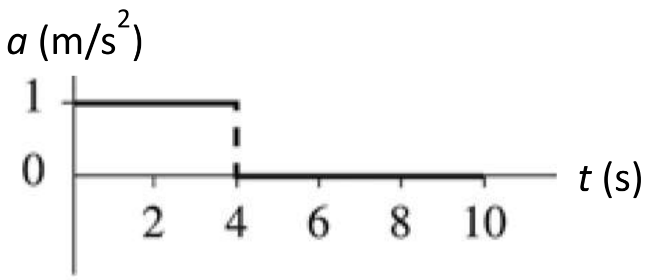
$$a = \frac{\Delta v}{\Delta t}$$

A linear decrease in velocity from t = 0 s to t = 2 s implies a constant negative acceleration. On the other hand, a constant velocity between t = 2 s and t = 4 s means zero acceleration.



8. Acceleration is the slope of the velocity-versus-time graph.

a.



b. From the acceleration-versus-time graph above, a at t = 3.0 s is +1 m/s^2.

9. To figure the acceleration we compute the slope of the velocity graph by looking at the rise and the run for each straight line segment.

Speeding up:

$$a = \frac{\Delta v}{\Delta t} = \frac{0.75\, m/s}{0.05s} = 15\, m/s^2$$

Slowing down:

$$a = \frac{\Delta v}{\Delta t} = \frac{-0.75\, m/s}{0.15s} = -5\, m/s^2$$

10. The trickiest part is reading the values off of the graph.

A. $$a = \frac{\Delta v}{\Delta t} = \frac{5.5\, m/s - 0.0\, m/s}{0.9s - 0.0s} = 6.1\, m/s^2$$

B. $$a = \frac{\Delta v}{\Delta t} = \frac{9.3\, m/s - 5.5\, m/s}{2.4s - 0.9s} = 2.5\, m/s^2$$

C. $$a = \frac{\Delta v}{\Delta t} = \frac{10.9\, m/s - 9.3\, m/s}{3.5s - 2.4s} = 1.5\, m/s^2$$

11. Remember, 50 ms = 0.050 s

$$a = \frac{\Delta v}{\Delta t} = \frac{3.5\,m/s}{0.050s} = 70\,m/s^2$$

Frogs are quite impressive!

12. For the gazelle:

$$a = \frac{\Delta v}{\Delta t} = \frac{13\,m/s}{3.0s} = 4.3\,m/s^2$$

For the lion:

$$a = \frac{\Delta v}{\Delta t} = \frac{9.5\,m/s}{1.0s} = 9.5\,m/s^2$$

For the trout:

$$a = \frac{\Delta v}{\Delta t} = \frac{2.8\,m/s}{0.12s} = 23\,m/s^2$$

The trout is the animal with the largest acceleration. A lion would have an easier time snatching a gazelle than a trout.

13. Acceleration is the rate of change of velocity:

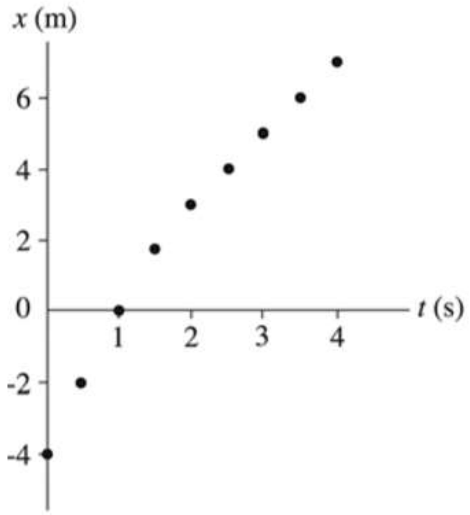
$$a = \frac{\Delta v}{\Delta t}$$

$$a = \frac{\Delta v}{\Delta t} = \frac{4.0\,m/s}{0.11s} = 36\,m/s^2$$

14. This is a unit conversion problem.

$$a = \frac{\Delta v}{\Delta t} = \frac{150\,km/h}{0.50s}\left(\frac{1000m}{1km}\right)\left(\frac{1h}{60min}\right)\left(\frac{1min}{60s}\right) = 83\,m/s^2$$

15. a.



b. $\Delta x = x$ (at t = 1 s) – x (at t = 0 s) = 0 m – (–4 m) = 4 m

c. $\Delta x = x$ (at t = 4 s) – x (at t = 2 s) = 7 m – 3 m = 4 m

d. From t = 0 s to t = 1 s,

$$v = \frac{\Delta x}{\Delta t} = \frac{4m}{1s} = +4\, m/s$$

e. From t = 2 s to t = 4 s,

$$v = \frac{\Delta x}{\Delta t} = \frac{4m}{2s} = +2\, m/s$$

f. The average acceleration is

$$a = \frac{\Delta v}{\Delta t} = \frac{2\, m/s - 4\, m/s}{2s - 1s} = -2\, m/s^2$$