mousetrap_acceleration.2

**Assigned Wed. 11.07.07**

**Due Thursday 11.08.07**

The mousetrap car accelerates with an almost constant acceleration. The problems below will assume a constant acceleration.

Newton's equations of motion will be used

• *d,s, or x* stands for distance or displacement (the vector form of distance) and must be converted to meters

• *v* stands for velocity (usually a lowercase v is used) and must be in m/s. Since the direction of motion for the mousetrap car is assumed velocity and speed are interchangeable

• *a* stands for acceleration and will always be in $m/s^2$.

• *t* stand for time and must always be in seconds

• The subscript $_o$ is pronounced "sub-naught" and stands for the *initial* velocity or displacement

$d = d_0 + v_0 t + \frac{1}{2}at^2$ **This is the big daddy of all motion equations All the other equations are derived from this one**

Example: A mousetrap car starts from rest and travels 12 m in 4.5 s. What is the acceleration of the car?
It initial velocity is 0 and we can set its initial displacement to zero as well

$$d = \cancel{d_o} + \cancel{v_o}t + \tfrac{1}{2}at^2$$
$$d = 0 + 0 + \tfrac{1}{2}at^2$$
$$d = \tfrac{1}{2}at^2$$
$$\frac{2d}{t^2} = a$$
$$\frac{2 \cdot 12m}{(4.5s)^2} = 1.2 \,{}^{m}\!/\!{}_{s^2}$$

$$a = \frac{v_{final} - v_o}{t}$$

Another way of stating this is that acceleration is the change in velocity over the change in time

In the previous problem in which we determined that the acceleration was 1.2 m/s$^2$, what is the velocity of the car just as it reaches the 12 meter mark?

*ans:* This takes 4.5 seconds so

$$v_{final} = v_o + at$$

$$v_{final} = 0 + 1.2\,{}^{m}\!/\!_{s^2} \cdot 4.5s = 5.4\,{}^{m}\!/\!_{s}$$

Notice how the units come out nicely to units of velocity (good units, they should get a treat)

$$v_{average} = \frac{1}{2}\left(v_0 + v_{final}\right)$$

What is the average velocity of the car in the first 4.5 s?

You get the average the way you get the average of anything, add them up and divided by the number

For this problem the average velocity is just 1/2 of the velocity at the end of the acceleration or simply

**2.7 m/s = average velocity**

**The mousetrap car only accelerates as long as the the string is pulling on the axle (producing a torque). That is why you want the string to come free after the mousetrap has unwound. After this, the car drifts to a stop with friction providing a negative acceleration**

The mousetrap drifts for another 35 ft (divide by 3.28 to get 10.7 m). What is the acceleration due to friction?

One of the most useful formulas in motion is

$$v^2 = v_o^2 + 2ad$$

notice you do not need time for this formula

$0 = \left(5.4\ {}^{m}\!/\!_{s}\right)^2 + 2a \cdot 10.2m$

$-29.16 = 2a \cdot 10.2m$

$-\dfrac{29.16}{2 \cdot 10.2m} = a$

$-1.4\ {}^{m}\!/\!_{s^2} = a$

**Your turn**

1. A mousetrap car accelerates for 5.3 s and travels 26 ft.

(a) What is 26 ft in meters?

*ans. 7.9 m*

(b) What is the acceleration of the car?

*ans 0.56 m/s*$^2$

2. What is the velocity of the car as it reaches the end of the string at 26 ft?

*ans 3.0 m/s*

3. What is the average velocity of the car during this period?

*ans. 1.5 m/s*

4. If the car then drifts another 42 ft, what is the acceleration that brings the car to a stop?

*ans -0.35 m/s*$^2$