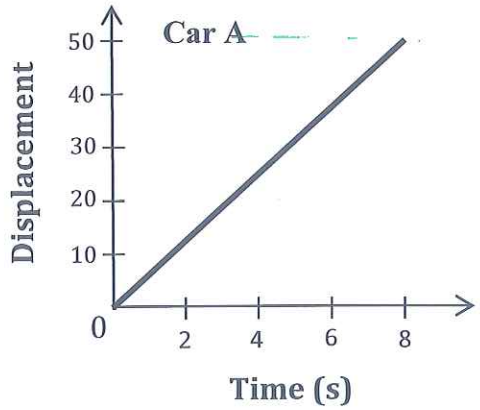
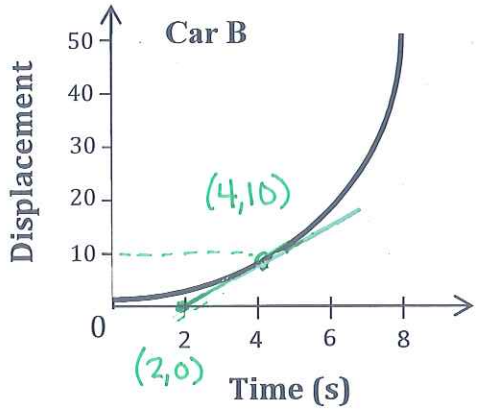
KINEMATICS REVIEW: DISPLACEMENT, VELOCITY, ACCELERATION, FALLING & THROWING

Instructions: *Show all work and units clearly according to the problem-solving criteria!*

1. The *d-t* graphs below represent the motion of Car A and Car B.





a. Qualitatively describe the motion of the 2 cars. Which car is moving faster at 8 seconds?

Car A is moving at a constant velocity. (a=0)
Car B is accelerating (speeding up) (a= constant)
Car B is moving faster at 8 seconds (steeper slope)

b. Which car has the greater average speed? (Show you work!)

$\bar{V}_A = \frac{d_2-d_1}{t_2-t_1} = \frac{(50-0)m}{(8-0)s} = 6.3\,m/s$

$\bar{V}_B = \frac{d_2-d_1}{t_2-t_1} = \frac{(50-0)m}{(8-0)s} = 6.3\,m/s$

Same average speed!

c. Calculate the instantaneous velocity of both cars at 4 seconds.

V_A = slope $= \frac{d_2-d_1}{t_2-t_1} = \frac{(50-0)m}{(8-0)s} \Rightarrow V_{A@4s} = 6.3\,m/s$

V_B = slope of tangent $= \frac{d_2-d_1}{t_2-t_1} = \frac{(10-0)m}{(4-2)s} = \frac{10m}{2s} \Rightarrow V_{B@4s} = 5.0\,m/s$

2. Leonard is snowboarding and he is gliding along at 8.0 m/s.

a. If it takes 8.0 seconds to go from one chairlift pole to another on a flat surface, how far apart are the poles?

$\bar{V} = 8.0\,m/s$
$t = 8.0\,s$
$d = ?$

$d = \bar{V} \cdot t$
$= (8.0\,m/s)(8.0\,s)$

$d = 64\,m$

b. How long would it take Leonard to go from one pole to another if his speed was 11 m/s?

$\bar{V} = 11\,m/s$
$d = 64\,m$
$t = ?$

$d = \bar{V} \cdot t \Rightarrow t = \frac{d}{\bar{V}}$

$t = \frac{64m}{11\,m/s}$

$t = 5.8\,s$

3. Suddenly, our fearless Leonard finds himself on a ski lift that has stopped. He realizes that his physics knowledge can help him as he is anxious to shred

a. He spits over the edge of the chair and it hits the slope after 1.8 seconds. How far is he above the ground?

down is +dir

$t = 1.8\text{s}$
$V_1 = 0\text{m/s}$
$a = 9.80\text{m/s}^2$
$d = ?$

$d = V_1 t^{0} + \frac{1}{2}at^2$
$= \frac{1}{2}(9.80\text{m/s}^2)(1.8\text{s})^2$

$\boxed{d = 16\text{m}}$

b. If he were to jump (don't try this!), what would be Leonard's instantaneous velocity just before he hit the ground?

$V_1 = 0$
$a = 9.80\text{m/s}^2$
$t = 1.8\text{s}$
$V_2 = ?$

$V_2 = V_1^{0} + at \quad (v = gt)$
$= (9.80\text{m/s}^2)(1.8\text{s})$

$\boxed{V_2 = 18\text{m/s}}$

c. If $1\ ^{\text{mi}}/_{\text{hr}} = 0.447\ ^{\text{m}}/_{\text{s}}$, convert his speed from $^{\text{m}}/_{\text{s}}$ to $^{\text{mi}}/_{\text{hr}}$.

$18\ ^{\text{m}}/_{\text{s}} \left| \frac{1\ ^{\text{mi}}/_{\text{hr}}}{0.447\ ^{\text{m}}/_{\text{s}}} \right. = \boxed{39\ ^{\text{mi}}/_{\text{hr}}}$ ← don't try jumping off a ski lift

4. Howard is comparing two cars going down the freeway: Car A travels 200. meters in 15 seconds and Car B travels 500. meters in 24 seconds.

a. Which car has the greater velocity? (Show your work completely)

A: $d = 200.\text{m}$, $t = 15\text{s}$
B: $d_B = 500.\text{m}$, $t_B = 24\text{s}$

$\bar{V} = \frac{d}{t}$ A: $\bar{V}_A = \frac{200.\text{m}}{15\text{s}} = 13\text{m/s}$

$\bar{V}_B = \frac{500.\text{m}}{24\text{s}} = 21\text{m/s}$

Car B

b. If the slower car wanted to accelerate in order to match the faster car's speed, what would their acceleration have to be in order to match the speed in 5.0 seconds?

$\Delta V = V_2 - V_1$
$V_2 = 21\text{m/s}$
$V_1 = 13\text{m/s}$ $a = ?$
$t = 5.0\text{s}$

$a = \frac{V_2 - V_1}{t}$
$= \frac{21\text{m/s} - 13\text{m/s}}{5.0\text{s}}$

$\boxed{a = 1.6\text{m/s}^2}$

5. Sheldon loves trivia: How many **minutes** does it take light from the sun traveling at 3.0×10^8 $^{\text{m}}/_{\text{s}}$ to reach Jupiter, which is about 780×10^6 km away?

$\bar{V} = 3.0 \times 10^8\text{m/s}$
$d = 780 \times 10^6\text{km} = 780 \times 10^9\text{m}$
$t = ?$

$d = \bar{V} \cdot t \Rightarrow t = \frac{d}{\bar{V}} = \frac{780 \times 10^9\text{m}}{3.0 \times 10^8\text{m/s}} = 2600\text{s}$

$2600\text{s} \left| \frac{1\text{min}}{60\text{s}} \right. = 43\text{ min}$

$\boxed{t = 43\text{min}}$

6. Amy is an avid biker.

a. What is the acceleration of Amy if she goes from rest to 24 $^{\text{m}}/_{\text{s}}$ in 7.0 seconds?

$V_1 = 0\text{m/s}$
$V_2 = 24\text{m/s}$
$t = 7.0\text{s}$
$a = ?$

$a = \frac{V_2 - V_1}{t}$
$= \frac{(24 - 0)\text{m/s}}{7.0\text{s}}$

$\boxed{t = 3.4\text{m/s}^2}$

b. What was the average speed of Amy during that time interval?

$V_1 = 0\ m/s$
$V_2 = 24\ m/s$
$\bar{V} = ?$

$\bar{V} = \frac{V_1 + V_2}{2}$
$= \frac{0\ m/s + 24\ m/s}{2}$

$\boxed{\bar{V} = 12\ m/s}$

c. Amy sees a giant ramp in the road 43 meters ahead! She doesn't care for heights so she slams on the brakes! If her acceleration is -6.1 m/s^2, will she stop in time or is she doomed to launch off the ramp?!

$V_1 = 24\ m/s$
$V_2 = 0\ m/s$
$a = -6.1\ m/s^2$
$d = ?$

$V_2^2 = V_1^2 + 2ad \rightarrow d = \frac{-V_1^2}{2a}$
$d = \frac{-(24\ m/s)^2}{2(-6.1\ m/s^2)}$

$\boxed{d = 47m}$ → oh no! She's going to jump!!

7. Raj lets goes of a ball which rolls down a ramp with a constant acceleration of 5.0 m/s^2. If it takes the ball 3.0 seconds to reach the bottom of the ramp, how long is the ramp?

$V_1 = 0\ m/s$
$a = 5.0\ m/s^2$
$t = 3.0s$
$d = ?$

$d = V_1 t + \frac{1}{2}at^2$
$= 0 + \frac{1}{2}(5.0\ m/s^2)(3.0s)$

$\boxed{d = 23m}$

8. Bernadette is watching airplanes while waiting for her flight.
   a. A fully loaded 747 airplane has a minimum take-off speed of 84 m/s. If the thrust produced by the four massive engines allows it to accelerate at 2.36 m/s^2, how much time is required for the plane to take-off?

$V_2 = 84\ m/s$
$V_1 = 0\ m/s$
$a = 2.36\ m/s^2$
$t = ?$

$V_2 = V_1 + at \rightarrow t = \frac{V_2}{a}$
$t = \frac{84\ m/s}{2.36\ m/s^2}$

$\boxed{t = 36s}$

   b. Runways are usually constructed to twice the minimum take-off distance. How long should the runway be for a 747?

$V_1 = 0$
$V_2 = 84\ m/s$
$a = 2.36\ m/s^2$
$t = 36s$
$d = ?$

$d = V_1 t + \frac{1}{2}at^2$
$= 0 + \frac{1}{2}(2.36\ m/s^2)(36s)^2$
$d = 1495\ m \rightarrow \times 2 \rightarrow$

$\boxed{d = 3000m}$

9. Stuart drops a ball off of a tall rooftop 40. meters high.
   a. How long will it take to hit the ground below?

down is + dir

$V_1 = 0$
$d = 40.m$
$a = g = 9.80\ m/s^2$
$t = ?$

$d = V_1 t + \frac{1}{2}at^2 \rightarrow t = \sqrt{\frac{2d}{a}}$
$t = \sqrt{\frac{2(40.m)}{(9.80\ m/s^2)}}$

$\boxed{t = 2.9s}$

   b. How fast will it be traveling just before it hits the ground?

$V_1 = 0$
$a = g = 9.80\ m/s^2$
$t = 2.9s$
$V_2 = ?$

$V_2 = V_1 + at$
$= 0 + (9.80\ m/s^2)(2.9s)$

$\boxed{V_2 = 28\ m/s}$

10. Barry throws a ball straight up in the air at an initial speed of 30. m/s.

a. How long will it take to reach the top of its path?

$V_1 = 30\ m/s$

$V_2 = 0\ m/s$

$a = g = 9.80\ m/s^2$

$t = ?$

$V_2 = V_1 + at \rightarrow t = \frac{V_2 - V_1}{a}$

$t = \frac{0 - 30\ m/s}{-9.80\ m/s^2}$

$t = 3.1\ s$

b. How fast will it be going at that point?

$V_{top} = 0\ m/s$

c. What is it's acceleration at that point?

$a = g = -9.80\ m/s^2$

d. How high will the ball go?

$V_1 = 30\ m/s$

$V_2 = 0\ m/s$

$a = g = -9.80\ m/s^2$

$t = 3.1\ s$

$d = ?$

$d = V_1 t + \frac{1}{2} a t^2$

$= (30\ m/s)(3.1\ s) + \frac{1}{2}(-9.80\ m/s^2)(3.1)^2$

$d = 46\ m$

e. How fast will it be going just before the boy catches it?

$V_{bottom} = -30\ m/s$ ← same magnitude, just downwards!

11. Will fires a paintball gun straight up in the air, and the initial velocity of the bullet is 250 m/s:

a. How long will it stay in the air?

$V_1 = 250\ m/s$

$V_2 = 0\ m/s$

$a = g = 9.80\ m/s^2$

$t = ?$

$a = \frac{V_2 - V_1}{t} \rightarrow t_{up} = \frac{V_2 - V_1}{a}$

$t_{up} = \frac{0 - 250\ m/s}{-9.80\ m/s^2} = 26\ s \times 2 \rightarrow t_{total} = 51\ s$

b. How high will it go?

$V_1 = 250\ m/s$

$V_2 = 0$

$a = g = -9.80\ m/s^2$

$t_{up} = 26\ s$

$d = ?$

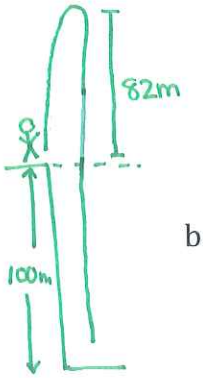
$d = V_1 t + \frac{1}{2} a t^2$

$= (250\ m/s)(26\ s) + \frac{1}{2}(-9.80\ m/s^2)(26\ s)^2$

$d = 3200\ m$

12. Leslie is standing on top of a 100. meter cliff when she throws a rock upwards at a speed of 40. m/s (wow, what an arm!). **Hint: For clarity, make a sketch of the situation.....*

a. How far up above the ground will it go before it starts to come down?



$V_1 = 40\ m/s$
$a = g = -9.80\ m/s^2$
$d = ?$
$V_2 = 0$

$V_2^{\nearrow 0} = V_1^2 + 2ad \rightsquigarrow d = \dfrac{-V_1^2}{2a}$

$d = \dfrac{-(40\ m/s)^2}{2(-9.80\ m/s^2)}$

$d = 82m$ ← above Cliff

$\boxed{d = 180m}$ ← above ground

b. How long will it take the rock to return to the girl's level?

$t_{up} = t_{down} \rightsquigarrow t_{to\ girl} = 2t_{up}$

$V_1 = 40\ m/s$
$V_2 = 0\ m/s$
$a = g = -9.80\ m/s^2$
$t_{up} = ?$

$V_2 = V_1 + at \rightsquigarrow t_{up} = \dfrac{V_2 - V_1}{a}$

$t_{up} = \dfrac{0 - 40\ m/s}{-9.80\ m/s^2}$

$t_{up} = 4.1s \rightsquigarrow t_{to\ girl} = 4.1 \times 2$

$\boxed{t = 8.2s}$

c. If she does not catch it and it falls to the base of the cliff, how long will it take for the rock to reach the ground from where she is standing?

$V_1 = 0\ m/s$
$a = g = -9.80\ m/s^2$
$d = -182m$
$t_{down} = ?$

$d = \cancel{V_1^{\nearrow 0} t} + \frac{1}{2}at^2 \rightsquigarrow t_{down} = \sqrt{\dfrac{2d}{a}}$

$t_{down} = \sqrt{\dfrac{2(-182m)}{(-9.80\ m/s^2)}}$

$t_{down} = 6.1s$

$t_{from\ her} = 6.1s - 4.1s$ ← from top to her

$\boxed{t = 2.0s}$

$t_{total} = 6.1 + 4.1 = 10.2s$

d. How fast will it be going just before it hits? Would you catch it?

$V_1 = 0$
$t = 6.1s$
$a = g = -9.80\ m/s^2$
$V_2 = ?$

$V_2 = \cancel{V_1^{\nearrow 0}} + at$

$= 0 + (-9.80\ m/s^2)(6.1s)$

$\boxed{V_2 = 60\ m/s}$ ← 134 mi/hr... I wouldn't catch that!