ABRHS PHYSICS (H) NAME: KEY

Acceleration Problems

1. An object has a velocity (in SI units) given by the expression $v = 3t^2 - 10t + 5$. If it starts at the origin, after 5 seconds:
   a. What is its acceleration?

$a = \frac{dv}{dt} = 6t - 10$ So $a(5) = 6(5) - 10 = \boxed{20\ m/s^2}$

   b. Where is it?

Since $v = \frac{dx}{dt}$

$x = t^3 - 5t^2 + 5t$ (just "undo" the derivative)

So $x(5) = (5)^3 - 5(5)^2 + 5(5)$

$= \boxed{25\ m}$

2. A Boeing 767 airplane can accelerate at a rate of 3.3 m/s^2. If a 767 starts from rest,
   a. How many seconds will it take to reach a take-off speed of 100 m/s?

$a = 3.3\ m/s^2$, $v_i = 0\ m/s$, $v_f = 100\ m/s$

$a = \frac{v_f - v_i}{t}$ $3.3 = \frac{100 - 0}{t}$ $\boxed{t = 30.3\ s}$

   b. How far would it travel in that time?

$x = \frac{1}{2}at^2 + v_i t + x_i$

$x = \frac{1}{2}(3.3)(30.3)^2 = \boxed{1515\ m}$

   c. What would be the average speed of the plane over this interval?

$\bar{v} = \frac{\Delta x}{t} = \frac{1515}{30.3} = \boxed{50\ m/s}$ or $\bar{v} = \frac{v_i + v_f}{2} = \frac{0 + 100}{2}$, $v_f = 50$

3. Carly constantly accelerates from rest, covering a distance of 20 meters in a time of 3.0 seconds.
   a. What was Carly's acceleration?

$v_i = 0\ m/s$, $\Delta x = 20\ m$, $t = 3\ s$

$\Delta x = \frac{1}{2}at^2 + v_i t$

$20 = \frac{1}{2}a(3)^2$ $\boxed{a = 4.44\ m/s^2}$

   b. What was her final velocity?

$v = at + v_i$

$= (4.44)(3)$ $\boxed{v = 13.3\ m/s}$

4. Sam is riding her bike with a speed of 5 m/s. She then constantly accelerates at a rate of 2 m/s^2.
   a. How long will it take her to reach a speed of 10 m/s?

$v_i = 5\ m/s$, $a = 2\ m/s^2$, $v_f = 10\ m/s$

$a = \frac{v_f - v_i}{t}$ $2 = \frac{10 - 5}{t}$ $\boxed{t = 2.5\ s}$

   b. How far will she travel in that time?

$\Delta x = \frac{1}{2}at^2 + v_i t$

$= \frac{1}{2}(2)(2.5)^2 + (5)(2.5)$

$\boxed{\Delta x = 18.75\ m}$

or $\bar{v} = \frac{v_i + v_f}{2} = \frac{5 + 10}{2} = 7.5\ m/s$

$\bar{v} = \frac{\Delta x}{t}$ → $7.5 = \frac{\Delta x}{2.5}$ $\Delta x = 18.75$

Acceleration Problems

5. Lewbert is traveling with a constant speed of 20 m/s when he passes T-Bo, who has a speed of 5 m/s. When Lewbert is 50 meters ahead of T-Bo, T-Bo tries to catch up to Lewbert with a constant acceleration of 4 m/s². How fast is T-Bo going when he passes Lewbert?

$v_L = 20$ m/s
$v_{T_i} = 5$ m/s
$a_T = 4$ m/s²

Lewbert → 20 m/s ---- T-Bo
50 m

$x_L = 20t + 50$
$x_T = \frac{1}{2}(4)t^2 + 5t$
$20t + 50 = 2t^2 + 5t$
$2t^2 - 15t - 50 = 0$
$t = \frac{15 \pm \sqrt{15^2 - 4(2)(-50)}}{2(2)}$
$t = \frac{15 \pm 25}{4}$
$t = 10$ s

$v_T = 4t + 5$
$= 4(10) + 5$
$v_T = 45$ m/s

6. Gibby is driving with a constant acceleration and travels a distance of 120 meters in 4 seconds. He has a final speed of 40 m/s. What was his acceleration?

$\Delta x = 120$ m
$t = 4$ s
$v_f = 40$ m/s

$\bar{v} = \frac{\Delta x}{t} = \frac{120}{4} = 30$ m/s
$\bar{v} = \frac{v_i + v_f}{2} \rightarrow 30 = \frac{v_i + 40}{2}$
$v_i = 20$ m/s

$a = \frac{v_f - v_i}{t} = \frac{40 - 20}{4}$
$a = 5$ m/s²

7. Spencer has a constant acceleration of 3 m/s² for a distance of 50 meters. His final velocity is 20 m/s. How long did it take him to travel that distance?

$a = 3$ m/s²
$\Delta x = 50$ m
$v_f = 20$ m/s

$v_f^2 = v_i^2 + 2a\Delta x$
$(20)^2 = v_i^2 + 2(3)(50)$
$v_i^2 = 100$
$v_i = 10$ m/s (or $v_i = -10$ m/s)

$\bar{v} = \frac{v_i + v_f}{2} = \frac{10 + 20}{2} = 15$ m/s
$\bar{v} = \frac{\Delta x}{t} \rightarrow 15 = \frac{50}{t}$
$t = 3.33$ s

OR $v_i = -10$ m/s
$\bar{v} = \frac{-10 + 20}{2} = 5$
then
$5 = \frac{50}{t}$
$t = 10$ s

Goes backwards first, then forwards

8. Starting from rest, Freddie has a constant acceleration for 7 seconds. He then slows to a stop with a different constant acceleration in 12 seconds. He traveled a total of 90 meters. What was his maximum speed?

$t_1 = 7$ s
$t_2 = 12$ s
$d_1 + d_2 = 90$ m

0 m/s — d_1, t_1 — d_2, t_2 — 0 m/s
Max V!

$\bar{v} = \frac{\Delta x}{t} = \frac{90}{7+12} = 4.74$ m/s

For either $\frac{1}{2}$ $\bar{v} = \frac{v_i + v_f}{2}$

$4.74 = \frac{0 + v_f}{2}$ (or $\frac{v_i + 0}{2}$)

$v_f = 9.47$ m/s (or $v_i = 9.47$)