Chapter 2 Discussion
1D Kinematics

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1. A child rides a pony on a circular track whose radius is 4.50 m.

   (a) Find the distance traveled and the displacement after the child has gone halfway around the track. 14.1m

   (b) Does the distance traveled increase, decrease, or stay the same when the child completes one circuit of the track? Explain. Increase

   (c) Does the displacement increase, decrease, or stay the same when the child completes one circuit of the track? Explain. decrease

   (d) Find the distance and displacement after a complete circuit of the track.

distance : 28.1m
displacement : 0m

(a)

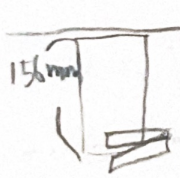
$2\pi(4.5) \div 2 = 14.1m$

(b) Increase distance is how much ground an object has covered

(c) decrease It will be 0, decrease, measure of how far out of place is an object.

2. A friend challenges you to a bar bet: they will hold a $20 bill vertically with one edge just at the level of your fingers, and if you are able to catch the bill before it falls through your fingers (it will be dropped without warning), you can keep it! Neglecting the amount of time it takes to send a nerve impulse to and from your brain (nerve transmissions move at about 100 m/s), what reaction time would be required to just barely catch the opposite edge of the bill when it's dropped? US bank notes are 156 mm across.

$\therefore 0.178s$



$t=0 \quad y = y_0 + V_{y_0}t + \frac{1}{2}at^2$

$156_{mm} = 0 + 0 + \frac{1}{2}(+9.8)t^2$

$0.156m = \frac{1}{2}(9.8)t^2$

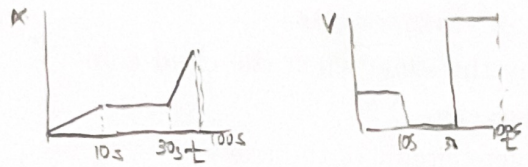
$t = 0.178s$

3. Sketch position-vs-time and velocity-vs-time graphs for the following motions. Include a numerical scale on both axes with units that are reasonable for this motion.

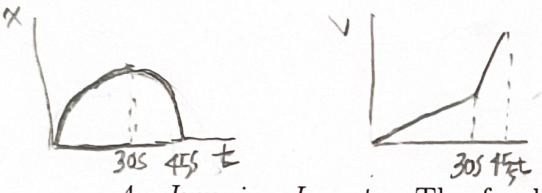
   (a) A student walks to the bus stop, waits for the bus, then rides to campus. Assume all motion is along a straight street.

   (b) A student walks slowly to the bus stop, realizes he forgot his paper that is due, and quickly walks home to get it.

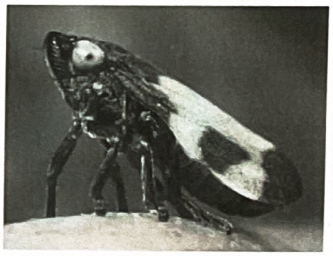
(a)



(b)



4. *Jumping Insects:* The froghopper *Philaenus spumarius* is supposedly the best jumper in the animal kingdom. To start a jump, this insect can accelerate at 4.00 km/s^2 over a distance of 2.00 mm as it straightens its specially adapted "jumping legs". Assume the acceleration is constant.



   (a) Find the upward velocity with which the insect takes off. $\boxed{4\,m/s}$

   (b) In what time interval does it reach this velocity? $\boxed{0.001\,s}$

   (c) How high would the insect jump off the ground if air resistance were negligible? (The actual height it reaches is about 70 cm, so air resistance must be a noticeable force on the leaping froghopper.) $\boxed{0.816\,m}$

(a)(b)

$x = x_0 + V_0 t + \frac{1}{2}at^2$

$2\times10^{-3}m = \frac{1}{2}at^2$

$\frac{2\times10^{-3}}{2000} = t^2$

$10^{-6} = t^2$

$\boxed{10^{-3} = t}$

$V = V_0 + at$

$V = 0 + (4000 m/s^2)t$

$V = 0 + (4000 m/s^2)(10^{-3})$

$\boxed{= 4\,m/s}$

(c)

$y = y_0 + V_{y_0}t + \frac{1}{2}at^2$

$V_y = V_0 + at$

$0 = 4 + (-9.8)t$

$\frac{20}{49} = t$

$h = 0 + 4\left(\frac{20}{49}\right) + \frac{1}{2}(-9.8)\left(\frac{20}{49}\right)^2$

$= \frac{40}{49} = \boxed{0.816\,m}$

5. A woman, driving her car west along a straight road, suddenly sees an obstacle in front of her. As quickly as possible, she applies her brakes. Her position after she applies her brakes is then described by

$$x(t) = 15 \text{ m} + (20 \text{ m/s})t - (1.3 \text{ m/s}^2)t^2$$

where t (in seconds) is the time elapsed since application of the brakes, and $x = 0$ was her position when she saw the obstacle.

(a) What distance along the road does the woman travel between the instant that she sees the obstacle and the instant when she applies the brakes? $\boxed{15\text{m}}$

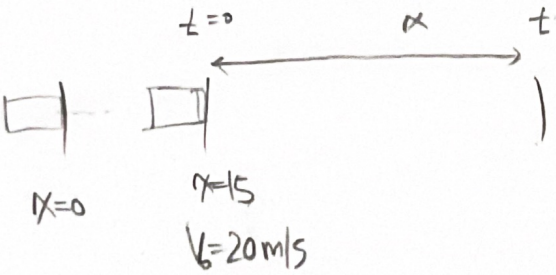
(b) What is the velocity of the woman's car at any time t after that? $\boxed{20 - 2.6t}$

(c) What is the velocity of the woman's car at the instant when she applies the brakes? $\boxed{20\text{m/s}}$

(d) What time elapses between the instant when the woman applies her brakes and the time when her car comes to rest? $\boxed{\frac{100}{13}\text{ s}}$

(e) What is the car's acceleration at any time while the woman applies her brakes? $\boxed{-2.6\text{m/s}^2}$

$a = -2.6 \text{ m/s}^2$



$V = V_0 + at$

$20 + (-2.6)t$

(d)

$0 = 20 - 2.6t$

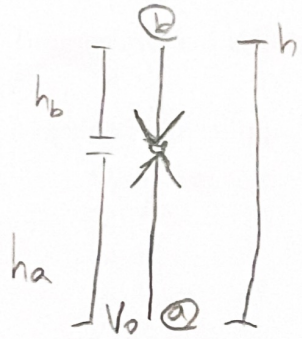
$\frac{100}{13} = t$

6. A rubber ball is shot straight up from the ground with speed v_0. Simultaneously, a second rubber ball at height h directly above the first ball is dropped from rest.

   (a) At what height above the ground do the balls collide? (Your answer will be an algebraic expression in terms of h, v_0, g.) $h - \frac{h^2 g}{2V_0^2}$

   (b) What is the maximum value for h for which a collision occurs before the first ball falls back to the ground? $\boxed{h_{max} = \frac{2V_0^2}{g}}$

   (c) For what value of h does the collision occur at the instant when the first ball is at its highest point? $\boxed{h = \frac{V_0^2}{g}}$



(b) when we want to make h larger, collision has to be near the ground

$h_a = 0$

$0 = h - \frac{h^2 g}{2V_0^2} = h\left(1 - \frac{hg}{2V_0^2}\right)$

$\boxed{h = 0}$ or $\frac{hg}{2V_0^2} = 1$, $\boxed{h = \frac{2V_0^2}{g}}$

doesn't make sense

(a)

$h = h_a + h_b$

$h = h_a + h_b = \frac{1}{2}gt^2 + V_0 t - \frac{1}{2}gt^2 = V_0 t$

$h = V_0 t$ $\quad t = \frac{h}{V_0}$

$y_a = y_0 + V_{y_0} t + \frac{1}{2}at^2$

$h_a = 0 + V_0 t + \frac{1}{2}(-g)t^2$, $h_a = V_0 t - \frac{1}{2}gt^2$

$h_a = V_0\left(\frac{h}{V_0}\right) - \frac{1}{2}g\left(\frac{h}{V_0}\right)^2$

$\boxed{= h - \frac{h^2 g}{2V_0^2}}$

$y_b = y_0 + V_{y_0} t + \frac{1}{2}at^2$

$h_b = 0 + 0 + \frac{1}{2}(g)t^2$

$h_b = \frac{1}{2}gt^2$

(c) $V_y = V_{0y} + at$

$0 = V_0 + (-g)t$, $t = \frac{V_0}{g}$ $\rightarrow$ $h_b = y_0 + V_{y_0} t + \frac{1}{2}at^2$

$h_b = 0 + 0 + \frac{1}{2}(g)\left(\frac{V_0}{g}\right)^2 = \frac{V_0^2}{2g}$

$h_a = y_0 + V_{y_0} t + \frac{1}{2}at^2$

$h_a = 0 + V_0\left(\frac{V_0}{g}\right) + \frac{1}{2}(-g)\left(\frac{V_0}{g}\right)^2 = \frac{V_0^2}{g} - \frac{V_0^2}{2g} = \frac{V_0^2}{2g}$

$h_a + h_b = \frac{V_0^2}{2g} + \frac{V_0^2}{2g} = \frac{V_0^2}{g}$