Kinematics Practice Problems

1. An airplane accelerates down a runway at 2.50 m/s^2 for 30 s. Determine the distance traveled during this time period if the plane starts from rest.

2. Greg drops a penny from the top of the Empire State Building (381 meters). Assuming no air resistance, what is the penny's speed when it hits the ground?

3. A car accelerates uniformly from 10 km/hr to 40 km/hr in a time of 6 seconds. What is the acceleration of the car (in m/s^2)?

4. A marble slides down a ramp with constant acceleration. The marble speeds up from rest to 8 m/s in a time of 5 seconds. How far did the marble travel?

5. A boy throws a ball straight up with a speed of 5.6 m/s. How high did the ball go?

6. Jason chucks a baseball straight up and waits 2.0 s for it to come back down. What was the initial speed that Jason threw the ball?

7. A red car accelerates uniformly from rest at a rate of 3 m/s^2. At the exact same time, a blue car accelerates from rest at a rate of 2.5 m/s^2. If they start from the same point, what is the distance between the cars after 10 seconds?

8. Car 1 is at rest at a red light. When the light turns green, Car 1 starts accelerating at a rate of 4.2 m/s^2. At the exact same time, Car 2 passes Car 1. If Car 2 is moving at a constant speed of 20 m/s, how long until Car 1 catches up to Car 2?

9. A kicker punts a football with an initial speed of 30 m/s at an angle of 42°. If the ground is completely flat, how far will the ball travel? (x direction only)

10. A cannon fires a projectile off the side of a cliff with an initial velocity of 100 m/s. If the cannon was aimed completely horizontally and the cliff is 30 m high, what will be the final speed of the projectile?

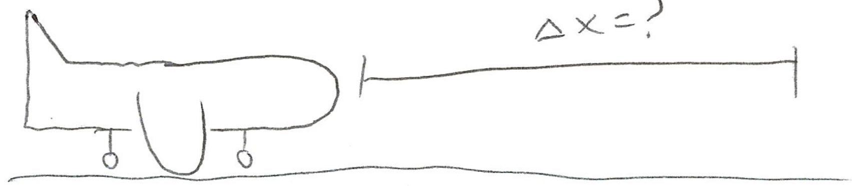
11. A golfer hits his ball onto the green. The green is elevated 2.1 meters. If the golfer hit the ball with a speed of 35 m/s at an angle of 55°, how far did the ball go? (x direction only)

12. Jake Elliot kicks a field goal with an initial velocity of 25.8 m/s at an angle of 34°. If the crossbar is 2 meters high and 15 meters away from the spot of the kick, was the kick good? (Did the ball go through the uprights?)

1.

rest ($V_i = 0$) $a = 2.50\ m/s^2$ $30s = t$

$\Delta x = ?$



$V_i = 0$

V_f

$a = 2.50$

$t = 30$

$\Delta x = ?$

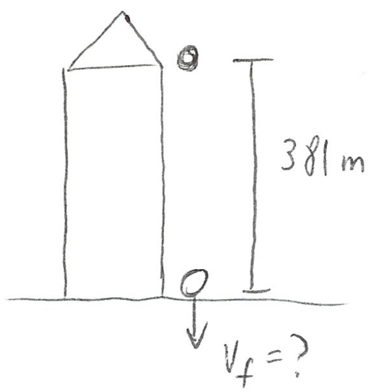
$$\Delta x = V_i t + \frac{1}{2} a t^2$$

$$\Delta x = 0(30) + \frac{1}{2}(2.50)(30)^2$$

$$\Delta x = 1125\ m$$

---

2. Assume dropped from rest



$a = -g = -9.8\ m/s^2$

$V_i = 0$

$V_f = ?$

$a = -9.8$

t

$\Delta y = -381$

↑ negative because it's moving downwards

$$V_f^2 = V_i^2 + 2a\Delta y$$

$$V_f^2 = 0^2 + 2(-9.8)(-381)$$

$$\sqrt{V_f^2} = \sqrt{7468}$$

$$V_f = 86.4\ m/s$$

3.

$$10\ \frac{km}{hr}\left(\frac{1000\ m}{1\ km}\right)\left(\frac{1\ hr}{60\ min}\right)\left(\frac{1\ min}{60\ s}\right) = 2.78\ m/s = V_i$$

$$40\ \frac{km}{hr}\left(\frac{1000\ m}{1\ km}\right)\left(\frac{1\ hr}{60\ min}\right)\left(\frac{1\ min}{60\ s}\right) = 11.1\ m/s = V_f$$

$t = 6s$

$a = ?$

$$V_f = V_i + at$$

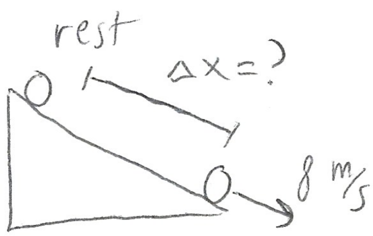
$$11.1 = 2.78 + a(6)$$

$$-2.78 \quad -2.78$$

$$\frac{8.33}{6} = \frac{6a}{6}$$

$$a = 1.39\ m/s^2$$

4.



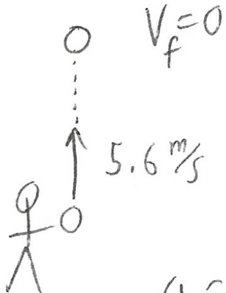
$t = 5\,s$

$$\Delta x = \frac{1}{2}(V_i + V_f)t$$

$$\Delta x = \frac{1}{2}(0+8)(5)$$

$$\Delta x = 20\,m$$

5.



$V_f = 0$ at peak height

$a = -9.8\,m/s^2$

$V_i = 5.6$

$V_f = 0$

$a = -9.8$

t

$\Delta y = ?$

$$V_f^2 = V_i^2 + 2a\Delta y$$

$$0^2 = (5.6)^2 + 2(-9.8)\Delta y$$

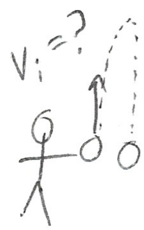
$$0 = 31.36 - 19.6\Delta y$$

$$+19.6\Delta y \qquad +19.6\Delta y$$

$$19.6\Delta y = 31.36$$

$$\Delta y = 1.6\,m$$

6.



$t = 2\,s$

$a = -9.8\,m/s^2$

$\Delta y = 0$ (ended where it started)

$$\Delta y = V_i t + \frac{1}{2}at^2$$

$$0 = V_i(2) + \frac{1}{2}(-9.8)(2)^2$$

$$0 = 2V_i - 19.6$$

$$+19.6 \qquad +19.6$$

$$19.6 = 2V_i \qquad V_i = 9.8\,m/s$$

7. Red Car

$v_i = 0$

v_f

$a = 3$

$t = 10$

$\Delta x = ?$

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

$\Delta x = 0(10) + \frac{1}{2}(3)(10)^2$

$\Delta x = 150\,m$

↑ Red car

Blue Car

$v_i = 0$

v_f

$a = 2.5$

$t = 10$

$\Delta x = ?$

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

$\Delta x = 0(10) + \frac{1}{2}(2.5)(10)^2$

$\Delta x = 125\,m$

↑ Blue car

$150 - 125 = 25\,m$

---

8. Car 1

$v_i = 0$

v_f

$a = 4.2$

$t = ?$

$\Delta x = d$ ← same d as car 2

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

$d = 0t + \frac{1}{2}(4.2)t^2$

Car 2

$a = 0$ (constant speed

$v = \frac{d}{t}$ ← use this equation when $a = 0$

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

plug in $d = 20t$

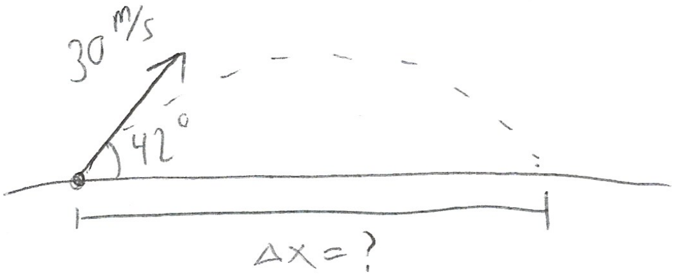
$20t = 0t + \frac{1}{2}(4.2)t^2$

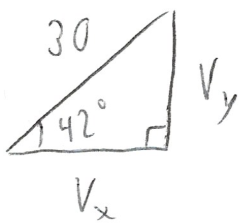
$\frac{20t}{t} = \frac{2.1t^2}{t}$ ← Note: In a math class, we can't divide by "t" here. But since t can't be zero seconds, we can eliminate t here.

$\frac{20}{2.1} = \frac{2.1t}{2.1}$

$t = 9.52\,s$

9.





$V_y = 30 \sin 42°$

$V_x = 30 \cos 42°$

y-axis

$V_i = 30 \sin 42° = 20.1$

V_f

$a = -9.8$

$t = ?$

$\Delta y = 0 \leftarrow$ ground is flat, which means $y_i = y_f$ and $\Delta y = 0$

$\Delta y = V_i t + \frac{1}{2} a t^2$

$0 = 20.1 t + \frac{1}{2}(-9.8) t^2$

$0 = t(20.1 - 4.9t)$

$t = 0$ (nonsense)

$20.1 - 4.9t = 0$

$20.1 = 4.9t$

$t = 4.10$

(use that time for x-axis)

x-axis

$a = 0$ (for x-axis)

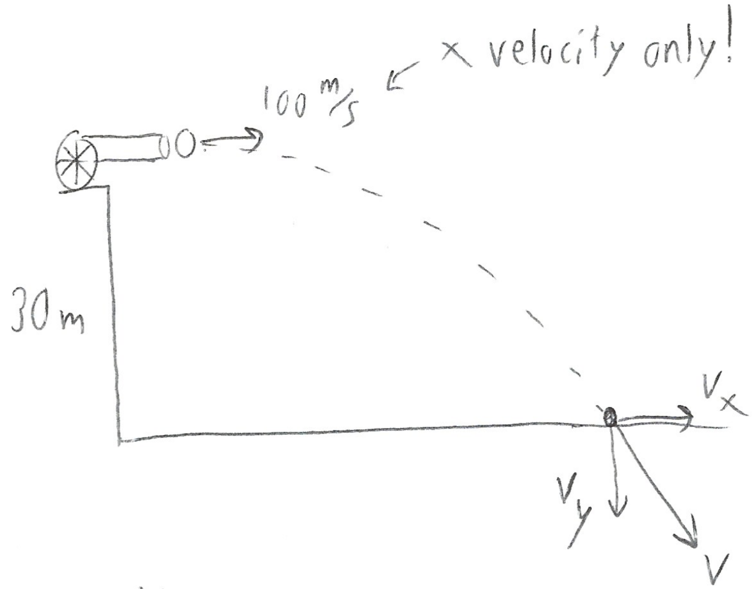
$V_x = \frac{\Delta x}{t}$

$30 \cos 42° = \frac{\Delta x}{4.10}$

$30 \cos 42° (4.10) = \Delta x$

$\Delta x = 91.4\,m$

10.



y-axis

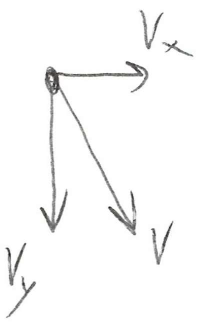
$V_i = 0$ ← for y-axis

$V_f = ?$

$a = -9.8$

t

$\Delta y = -30$ ← Negative because it's going down 30 m



Make a right triangle!

$V_x = 100$

$V_y = -24.2$

$V_f^2 = V_i^2 + 2a\Delta y$

$V_f^2 = 0^2 + 2(-9.8)(-30)$

$\sqrt{V_f^2} = \pm\sqrt{588}$

$V_f = -24.2 \text{ m/s}$

↑

We want to choose the negative square root because the velocity points down. However, you can miss this negative and still get the right answer.

$V = \sqrt{100^2 + (-24.2)^2}$

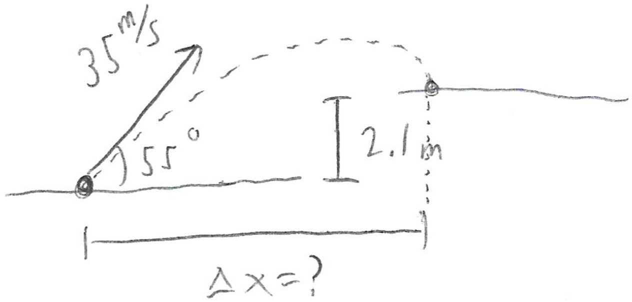
$V = \sqrt{10000 + 588}$

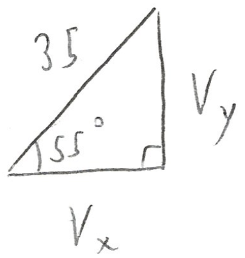
$V = 102.9 \text{ m/s}$

↑

Note: "speed" does not care about direction.

11.





$V_y = 35 \sin 55°$

$V_y = 28.7$ m/s

$V_x = 35 \cos 55°$

$V_x = 20.1$ m/s

~~x-axis~~

x-axis

$a = 0$

$V_x = \frac{\Delta x}{t}$

$20.1 = \frac{\Delta x}{5.78}$

$\Delta x = 20.1(5.78)$ $\quad \Delta x = 116$ m

y-axis

$V_i = 28.7$ (not 35)

V_f

$a = -9.8$

$t = ?$

$\Delta y = 2.1$ ← Positive because it's 2.1 m higher.

$\Delta y = V_i t + \frac{1}{2} a t^2$

$2.1 = 28.7t + \frac{1}{2}(-9.8)t^2$

$-2.1 \qquad -2.1$

$0 = -4.9t^2 + 28.7t - 2.1$

$t = \frac{-28.7 \pm \sqrt{(28.7)^2 - 4(-4.9)(-2.1)}}{2(-4.9)}$

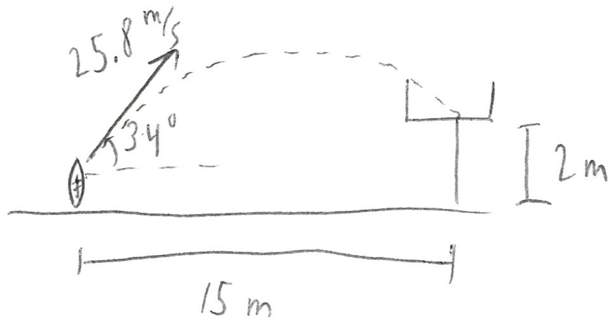
$t = \cancel{.077}$, 5.78

too small

$t = 5.78$ s

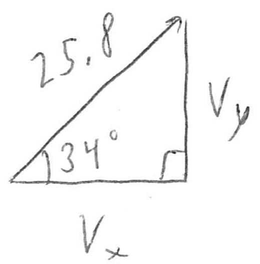
(use for t in x-axis)

12. Where to start... Let's draw a picture.



If $\Delta y > 2$, the field goal was good.

If $\Delta y \leq 2$, it missed



$V_y = 25.8 \sin 34°$

$V_y = 14.4 \text{ m/s}$

$V_x = 25.8 \cos 34°$

$V_x = 21.4 \text{ m/s}$

x-axis

$a = 0$

$V_x = \dfrac{\Delta x}{t}$

$21.4 = \dfrac{15}{t}$

$21.4t = 15$

$t = \dfrac{15}{21.4} = .701 \text{ s}$ (use for y-axis)

y-axis

$V_i = 14.4$

V_f

$a = -9.8$

$t = ? = .701$

$\Delta y = ?$

$\Delta y = V_i t + \frac{1}{2}at^2$

$\Delta y = 14.4(.701) + \frac{1}{2}(-9.8)(.701)^2$

$\Delta y = 7.69 \text{ m}$

↑

greater than 2 m

The kick was good!

(Go Birds!)