Section 2.4: Solving Problems Using Kinematics Formulae

1. A baseball traveling at 30.0 m/s strikes a catcher's mitt and comes to a stop while moving 10.0 cm within the mitt. Calculate the average acceleration of the ball.

$V_1 = 30.0\ m/s$
$V_2 = 0\ m/s$
$d = 10\ cm = 0.100\ m$
$a = ?$

$2ad = V_2^2 - V_1^2$

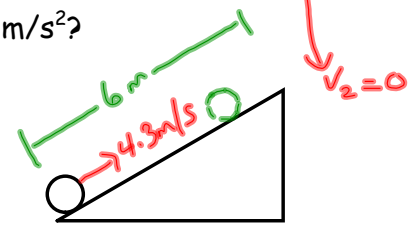
$a = \dfrac{V_2^2 - V_1^2}{2d}$

$a = \dfrac{(0\ m/s)^2 - (30\ m/s)^2}{2(0.100\ m)}$

$a = -4500\ m/s^2$

$(0 - 30^2) \div (2 \times 0.100)$

2. A ball rolls up a 6.0 m ramp. It is traveling at a velocity of 4.3 m/s up the ramp when at the bottom of the ramp. What distance will the ball be from the top of the ramp when it reaches its highest point, if the ramp is smooth and causes the ball to accelerate toward the bottom at a rate of 2.4 m/s^2?



length of ramp = 6.0 m
$V_1 = 4.3\ m/s$
$V_2 = 0\ m/s$
$a = -2.4\ m/s^2$
$d = ?$

$\dfrac{2ad}{2a} = \dfrac{V_2^2 - V_1^2}{2a}$

$d = \dfrac{0 - (4.3\ m/s)^2}{2(-2.4\ m/s^2)}$

$d = 3.85\ m$

$-(4.3)^2 \div (2 \times -2.4)$

distance from top = 6 m - 3.85 m
= 2.15 m
= 2.2 m

3. A car starts from rest at an intersection. It has an acceleration of 3.25 m/s^2. At the same time, a truck, with a constant velocity of 26 m/s, passes the car. How far apart will they be after 4.5 s?

Car	Truck
$v_1 = 0$	$v = 26\ m/s$
$a = 3.25\ m/s^2$	$t = 4.5\ s$
$t = 4.5\ s$	$d_T = ?$
$d_c = ?$	

$$d_c = v_1 t + \frac{1}{2}at^2$$
$$= \frac{1}{2}(3.25\ m/s^2)(4.5\ s)^2$$
$$= 32.9\ m$$

$$d_T = vt$$
$$= (26\ m/s)(4.5\ s)$$
$$= 117\ m$$

$$\Delta d = 117\ m - 32.9\ m = 84\ m$$

The truck and car are 84 m apart.

4 A car accelerates from rest at a rate of 4.0 m/s^2 and covers 120 m. Determine how long the car was accelerating.

$v_1 = 0$
$a = 4.0\ m/s^2$
$d = 120\ m$
$t = ?$

$$d = v_1 t + \frac{1}{2}at^2$$
$$d = \frac{1}{2}at^2$$
$$\frac{2d}{a} = \frac{at^2}{a}$$
$$\sqrt{\frac{2d}{a}} = t$$
$$\sqrt{\frac{2(120\ m)}{4.0\ m/s^2}} = t$$
$$7.7\ s = t$$

5. A bike moving at 12m/s accelerates at 4.0 m/s^2. How long will it take to experience a displacement of 80.0 m?

$V_1 = 12\,m/s$
$a = 4.0\,m/s^2$
$d = 80.0\,m$
$t = ?$

① Method 1: (sometimes)

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

✓ $80m = (12\,m/s)t + \frac{1}{2}(4.0\,m/s^2)t^2$

$80 = 12t + 2t^2$ – Quadratic Equation

$0 = 2t^2 + 12t - 80$ — Factor / Quadratic formula

$0 = 2(t^2 + 6t - 40)$

$0 = 2(t+10)(t-4)$

$t + 10 = 0 \quad t - 4 = 0$

~~$t = -10\,s$~~ $t = 4\,s$

The time is 4.0s

Method 2: Always works.

$V_1 = 12\,m/s$
$a = 4.0\,m/s^2$
$d = 80.0\,m$
$t = ?$
$V_2 = ?$

* If you don't want to factor → find V_2 first

$2ad = V_2^2 - V_1^2$

$2ad + V_1^2 = V_2^2$

$2(4.0\,m/s^2)(80\,m) + (12\,m/s)^2 = V_2^2$

$784\ m^2/s^2 = V_2^2$

Don't forget every # has 2 square roots. $\pm\sqrt{784\,m^2/s^2} = V_2$

$28\,m/s = V_2$

② Find time.

$a = \frac{V_2 - V_1}{t}$

$t = \frac{V_2 - V_1}{a}$

$t = \frac{28\,m/s - 12\,m/s}{4.0\,m/s^2}$

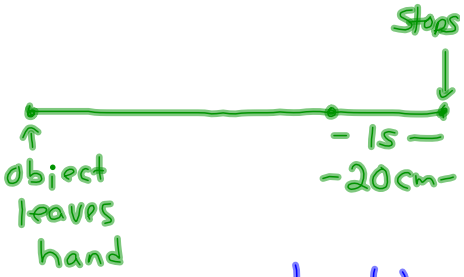
$t = 4.0\,s$

6. An object is pushed along a rough horizontal surface and released. It slides for 10.0 s before coming to rest and it travels a distance of 20.0 cm during the last 1.0 s of its slide.

(A) How fast was the object traveling upon release?

Whole
$t = 10.0\,s$
$V_2 = 0$
$V_1 = ?$
a

Last Second
$t = 1.0\,s$
$d = 20\,cm = 0.200\,m$
$V_2 = 0$
$a = ?$



*Need to find "a" during the last 1s of its slide. This acceleration is constant throughout the slide.

① $d = V_2 t - \frac{1}{2}at^2$

$d = -\frac{1}{2}at^2$

$-\frac{2d}{t^2} = \frac{at^2}{t^2}$

$\frac{-2(0.2m)}{(1s)^2} = a$

$-0.40\,m/s^2 = a$

② $a = \frac{V_2 - V_1}{t}$

$at = V_2 - V_1$

$V_1 = V_2 - at$

$V_1 = 0 - (-0.4\,m/s^2)(10s)$

$V_1 = 4.0\,m/s$

(B) How fast was it traveling when it reached the halfway position in its slide?

7 The Easter bunny runs along a straight path with a constant speed of 25 m/s. He passes a sleeping tortoise, who immediately starts to chase the bunny with a constant acceleration of 3.0×10^{-3} m/s^2. How long does it take the tortoise to catch the bunny?

8 A truck driving at 90.0 km/h applies the brakes to prevent from hitting a stalled car. In order to avoid a collision, the truck would have to be stopped in 20.0 s. At an average acceleration of 4.0 km/h/s, will a collision occur?

9 A driver of a car going at 90.0 km/h suddenly sees the lights of a barrier 45 m ahead. If the driver applies the brakes and the average acceleration during braking is 10.0 m/s^2, determine the whether or not the car hits the barrier. The driver's reaction time is 0.75 s.

10. Just as a traffic light turns green, a waiting car starts with a constant acceleration of 6.0 m/s^2. At the instant the car begins to accelerate, a truck with a constant velocity of 21 m/s passes in the next lane.

A How long will it take the car to catch the truck?

B How far apart will the vehicles have traveled in this time?

C How fast will the car be traveling when it overtakes the truck?