Unit 1 : Kinematics Review Problems

Key Topics

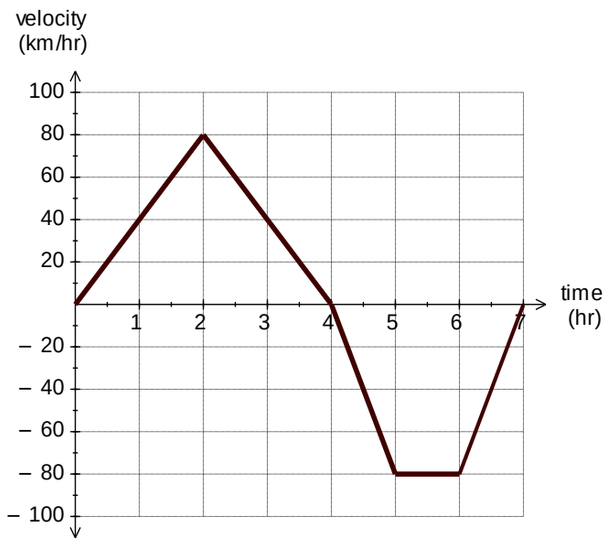
- Graphing
- Linear Kinematics Word Problems (Big "5" Equations)
- Vectors
- Projectiles

Part A : Word Problems & Graphing Review Problems

1. A 100m long train accelerates uniformly from rest. If the front of the train passes a railway worker 150m down the track at a velocity of 25 m/s, what will be the speed of the last car as it passes the worker?

2. The stopping distance of a car is a function of the reaction time of the driver, the acceleration (negative) of the car due to the brakes and the initial velocity. If a person's reaction time is 0.2s, the deceleration rate of the car is -6.0 m/s^2, what is the maximum speed a car could be going if it must stop within 20m when an obstacle is seen.

3. The graph to the right shows the velocity of a car driving along a straight road. Using this graph answer the following questions:



   a. Total distance travelled in first 4 hours.
   b. Total distance travelled in final 3 hours.
   c. Total displacement.
   d. Acceleration during the time period 0-2 hours.
   e. Acceleration during the time period 2-4 hours.
   f. Acceleration during the time period 4-5 hours.
   g. Acceleration during the time period 5-6 hours.
   h. Acceleration during the time period 6-7 hours.
   i. Average speed for the entire trip.
   j. Average Velocity for the entire trip.

Answers:

1. V_2=32.3 m/s (first calculate a=2.08m/s^2), **2.** 14.3 m/s **3a.** 160 km, **b.** 160 km, **c.** 0 km, **d.** 40km/hr^2, **e.** -40 km/hr^2, **f.** -80km/hr^2, **g.** 0 km/hr^2, **h.** 80 km/hr^2, **i.** 45.7km/hr, **j.** 0 km/hr

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Part B : Vectors

1. Two teams are competing in a local charity car rally. The first team (team A) follows the course instructions as detailed in their rules. They travel the prescribed rout of 10.0 km [E45°N], 9.00 km [W],11.4 km [W45°S] and finally 10.0 km [E]. Driving as fast as they can, Team A arrives at the finish line in 23 minutes.

Team B equipped with a four wheel drive Jeep, decides that they can figure out how to go directly from the starting point to the finish point without having to travel the entire route.

   a. What is the average speed of Team A?
   b. What is the displacement vector that Team B must follow to go directly to the Finish Line?
   c. What is minimum average velocity that team B can travel at, to arrive at the finish line at the same time as Team A? (you can ignore the time it takes Team B to compute their route).

2. An airplane is flying at a velocity of 300.0 m/s [W60°N] relative to the air. The velocity of the wind is 45 m/s [E]. Find the velocity of the plane relative to the ground.

3. A boat's motor will make it go 8.0 m/s. The boat starts on the south shore of a river that flows from west to east. It is pointed [N] across the river. The current in the river is 3.0 m/s [E] and the river is 40 m wide.

   a. How long will it take for the boat to cross the river?
   b. How far downstream will the boat land from the point that was straight across from where the boat started?
   c. What is the velocity of the boat with respect to the shore?
   d. If the boat wanted to go straight across the river, what heading would the boat have to follow so that it would move straight north?
   e. What is the boat's velocity with respect to the shore now?
   f. How long will it take for the boat to cross the river now?

Answers

1. a. 105 km/hr **b.** 1.0km[S], **c.** 2.6 km/hr [S] **2.** 280km/hr [W68°N]

3. a. 5s **b.** 15m[E] **c.** 8.5m/s[N21°E] **d.** [N22°W] **e.** 7.4m/s[N] **f.** 5.4s

Part C : Projectile Problems

Most projectile problems can be solved using a standard approach. Each type of projectile problem can be solved by following the same basic strategy:

1. Determine the horizontal and vertical components of the initial velocity:
   $V_{1v} = V_1 \sin(\theta)$
   $V_H = V_1 \cos(\theta)$
2. Using the vertical velocity component, find the flight time using:
   $d_v = V_{1v}t + \frac{1}{2}at^2$
3. Use the flight time to determine the horizontal distance using:
   $d_h = V_h t$ (since horizontal velocity is constant)
4. Find the final vertical velocity using:
   $V_{2v} = V_{1v} + at$ or $V_{2v}^2 = V_{1v}^2 + 2ad$
5. Recombine the final velocity components (the vertical and the horizontal which never changed) to get the magnitude and direction of the final velocity (using Pythagorean theorem and basic trig).

Sample Problems

Projected Horizontally from a height

1. A rock is thrown horizontally at 10.0 m/s from the top of a cliff 122.5m high.
a. How long does the rock take to hit the ground?
b. What is the horizontal displacement of the rock?
c. What vertical velocity does the rock strike the ground with?
d. What is the final velocity of the rock when it hits the ground?

2. An object is projected horizontally with a velocity of 30.0 m/s. It takes 4.0s to reach the ground. Neglecting air resistance, determine:
a. the height at which the object was projected.
b. the magnitude of the resulting velocity, just before the object hits the ground.

Projected at an angle and lands at same level it was shot from

Note : Special equations may help in some of these problems: $t = \frac{2V_1 \sin\theta}{g}$ $d_H = \frac{V_1^2 \sin(2\theta)}{g}$

3. A cannonball is fired with a velocity of 100 m/s at 25° [AH]. Determine how far away it lands on level ground.

4. A player kicks a soccer ball towards the goalkeeper, at an angle of 37°[AH] with an initial speed of 14.7 m/s. The goal keeper stands 26m from the kicker.
a. Where will the ball land relative to the goalkeeper?
b. If the goalkeeper watched the ball until it reached maximum height and then started to run at constant speed to just intercept the ball at ground level, how fast was he running?

Projected at an angle and lands at a different level then it was shot from

5. A hiker is standing on a cliff that is 60.0m high. He throws a stone with an initial velocity of 21m/s [35°AH]. How far from the base of the cliff does the stone land?

6. During baseball practice, a player retrieves a ball out of the bleachers. The ball is thrown back to the field at an angle of 42°[AH] with an initial velocity of 15 m/s. If the ball was 5.3m above the level of the field when it was thrown, what velocity will the ball hit the playing field with when it lands?

Answers: **1a.** 5s **b.** 50m **c.** 49 m/s [down] **d.** 50 m/s [78°BH], **2a.** 78m, **b.** 49 m/s
3. 780m **4a.** 4.8m in front **b.** 5.3 m/s **5.** 85m **6.** 18 m/s [52°BH]