Physics 20: Kinematics

** Keep in mind that this only covers the basics and you should still look over your own notes or things your teacher has provided you**

Formulae:

$\Delta v_{avg} = \frac{\Delta d}{\Delta t}$ $\Delta a_{avg} = \frac{\Delta v}{\Delta t}$ $d = v_i\, t + \frac{1}{2}at^2$

$d = v_f\, t - \frac{1}{2}at^2$ $d = \frac{(v_f + v_i)}{2}t$ $v_f^2 = v_i^2 + 2ad$

Key Concepts:

Uniform Motion

Uniform motion occurs when an object is travelling at a constant velocity. This means that the acceleration of the object is 0m/s/s. In these cases, the most common formula used will be the first formula in the formulae section, and you will solve for a variable.

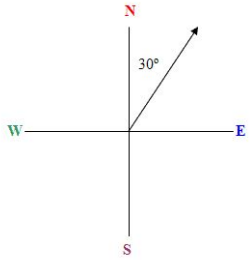
Uniform Acceleration

Uniform acceleration occurs when an object is not at a constant velocity, but is actually accelerating (in the positive or negative direction) at a constant rate. This means that there is always a force applied to the object that influences its velocity. For example, a pencil dropped from a high elevation will experience uniform accelerated motion, as it begins at a speed of 0m/s and reaches the floor at a significant speed due to gravitational acceleration.

Vectors in Two Dimensions

1. Describing a vector in 2-D:

Cardinal Direction: we will use the example 30 degrees East of North.



You begin North, and move 30 degrees towards East. You should always draw a diagram when doing problems involving cardinal directions! (In fact, you should always draw a diagram for any question that needs visualization.) 30 degrees E of N is the same as 60 degrees N of E, and if you first take East and go 60 degrees towards North, you will arrive at the same position.

There is also another ways of expressing cardinal direction. Still using the example above, [30 degrees E of N] could also be written as [N30E]. It's like saying I start from north and go 30 degrees east. The "of North" is replaced by putting "North" in front. Beginning with North as 0 degrees, and rotating clockwise, you can also express directions in terms of bearings and so [30 degrees] is also an acceptable representation of the position.

2. Adding vectors in 2-D

A 2D vector could be broken up into its horizontal (x) and vertical (y) components. 2D vector additions could be done by adding all the horizontal components together and adding all the vertical components together; then we use $R = \sqrt{x^2 + y^2}$ (pythagorean theorem) and $\theta = tan^{-1}(y/x)$ (trigonometric ratios) to find the magnitude and direction of the resultant vector. You should always be aware whether a component is positive or negative in your addition (depending on which direction you initially assign to be positive).

Try the two following ones if you are not confident of the process, and ask one of the peer tutors to help you if you need it!

1) Add 50.0km [30 degrees N of E] and 30.0 km [SW]
2) Add 6.0m [25 degrees S of W] and 4.0m [N]

Answer:

1) 14.6km [15.0 degrees N of E]
2) 5.6m [15 degrees N of W]

Projectiles

1. *Horizontal projectiles (example: throwing a ball off a roof)*

For horizontal projectiles, objects will experience uniform accelerated motion in the vertical plane (in most cases the acceleration is due to gravity; a=9.81m/s/s,) and uniform motion in the horizontal plane, meaning that the speed the object's horizontal velocity will be constant and often provided as initial velocity. The vertical displacement is often the height above the ground (the height of a building or cliff,) and the initial vertical velocity is in most cases 0m/s. In this case, you would know the displacement, initial velocity and acceleration, which will allow you to calculate the time or final velocity of the object.

It is important to remember that the time the object travels vertically is also the time it travels horizontally! This will allow you to use the information provided in the question to solve for both horizontal and vertical motion.

If the question asks you to solve for a vertical component, and you are only provided with two variables that correlate to this, see if you are able to *solve for time using horizontal components* provided, as then you will know three vertical components!

2. *General Projectiles (example: firing a cannon)*

In these situations, an object may be thrown upwards at an angle, traveling in an arc-like path. The horizontal component of motion will be the same as in horizontal projectiles (in uniform motion,) however, the velocity must be calculated using vector components from the initial velocity (often calculated as $cos(\theta_{angle\ to\ horizonal})\ v_i$. Likewise, the vertical component is not 0, and must also be calculated. This is often $sin(\theta_{angle\ to\ horizonal})\ v_i$.

The object will travel upwards opposing the acceleration due to gravity until it reaches a speed of 0m/s (equilibrium,) where it will fall back down to the earth, due to the downwards acceleration.

With these questions, it is important to consider direction within the calculation either with square brackets indicating [up or down] or with positive and negative signs. If the question is not asking for the greatest height reached, then you can solve for components in one calculation! Often you will solve for time, in which you will be faced with a quadratic equation which can be solved using basic math principles. If asked for the greatest height reached, simply solve using known variables of acceleration, initial velocity (if given) and final velocity (being 0m/s at greatest height.)

If the object is being thrown from ground-level like a baseball thrown upwards, which falling back down, the displacement of the object is 0m. If the object is being

thrown upwards from a higher elevation (like from a building to the ground) the displacement would be the negative of the height of the building. Likewise, the object may be thrown downwards from a cliff, and in that case, both the height of the cliff and the initial vertical velocity will be negative! A diagram or table with components may be helpful to organize given information to solve the question!

Relative Motion

Relative motion is a concept explored when an object is moving within an environment that is also moving. The relative velocity of an object within an environment is equal to its velocity observed relative to a still observer/viewpoint (such as the ground,) added to the velocity of the environment as observed by the same still viewpoint.

Using variables, this is expressed as ${}_{a}v_{b} + {}_{b}v_{c} = {}_{a}v_{c}$. (This is read as: the velocity of a with respect to b combined with the velocity of b with respect to c is equal to the velocity of a with respect to c)

*Note these are vector additions, and so the direction of motion must be taken into consideration. This can be done by using positive and negative signs to represent directions. You may also be required to add horizontal components of vectors and vertical components of vectors to determine a resultant vector.

If there are two different objects P and Q travelling at velocities v_p and v_q respectively relative to an observer, then the the velocity of P relative to Q is calculated as $v_{rel} = v_p - v_q.$ The velocities are calculated as vectors.

Remember to check that the units of your response are the same as those provided as answer choices! They will trick you in unit tests!

Practice Questions:

1. An object goes from 0 to 100 real quick (accelerates uniformly from 0 km/h to 100 km/h in 20 seconds). What is the average acceleration?

2. An object accelerates at a rate of +514 cm/s^2 from rest for 5 minutes. What is the final velocity?

3. From some random velocity, an object reaches a velocity of 0m/s over 15 seconds. It accelerates uniformly at -10m/s^2 (referring to the negative direction), what is the initial velocity?

4. An object is dropped at 15m, how long does it take to fall and what is the final speed?

5. The same object is thrown off a 30 m tall building with an initial velocity of 3.5m/s[forward]. How far away from the building is the object at the end of the fall?

6. A cannon is fired from ground level with an initial velocity of 135 m/s $[50.0^o \textit{ above the horizon}]$. What is its velocity when it comes in contact with the ground during impact and what is the displacement it travels?

7. The driver of a truck travelling at 50.5 km/h [forward] presses on the gas pedal and causes an acceleration of 2.25 m/s^2. If the time to accelerate is 4.20 s, what is the final velocity of the truck?

8. A woman is driving on the highway at 85.0 km/h. She notices that the traffic is stopped down the road. If the woman's reaction time for stepping on the brakes is 0.750s, what distance will she travel before she steps on the brakes?

9. A vehicle experiencing acceleration at -7.00 m/s^2 travels a displacement of +550 m in 6.00 s. What was the initial velocity of the vehicle?

10. An object travelling in a straight line at 50 m/s accelerates at –4.5 m/s^2 for 8.5 s. What is the final velocity of the object?

11. In still water, a person can paddle a canoe at 2.5 m/s. They wish to cross a river which flows at 5.5 m/s [West] and is 120 m wide. If the person points the canoe directly North across the river, how long does it take for the canoe to cross?
    What is the final displacement of the canoe from its original position?

12. The driver of a car travelling at 65 km/h [E], steps on the brakes and uniformly decelerates and stops in 4.0 s. What is the average acceleration of the car (in m/s^2) while braking?

IF THERE IS ANY CONFUSION ABOUT TOPICS COVERED, ANY OF OUR STUDY SPACE MENTORS WOULD BE HAPPY TO HELP YOU OUT!(: