**Position-Time Graphs**

* Purpose: Describes the motion from a position over time, including location, direction of motion, speed, whether speeding up or slowing down, direction of acceleration
* Left/west/north/etc. or right/east/south/etc. movement represented by + or - (choose which direction is which)
  + Lack of movement is a straight horizontal line
  + Constant velocity is a straight diagonal line
  + Constant/uniform acceleration is like half of a parabola
  + Steeped as it speeds up, less steep as it slows down
* The shape tells us…
  + Slope: Velocity and Direction
  + Steepness: Speed
  + Positive/Negative: Position Relative to the Sensor/Origin



* This graph tells you that… (assuming it was drawn perfectly)
  + The object starts out in the negative direction away from the sensor
  + It begins to move at a constant rate in the positive direction
  + It briefly stops before turning around and accelerating a little bit in the negative direction again
  + Finally, it stops again

**Velocity-Time Graphs**

* Purpose: Describes the change in velocity of an object over time
* The shape tells us…
  + X-Axis: Turning around/staying still
  + Positive/Negative: Direction
* Derivative of the Position-Time Graph

**Average Rates on a Position-Time (x-t) Graph**

* ∆*x*/∆*t* = Rate of change of time
  + ∆*x* = *xf* - *xi*
  + *∆t* = *tf* - *ti*
* Slope of the secant between the two points (starting and ending points)

**Instantaneous Rates on a Position-Time (x-t) Graph**

* Choose two points along the tangent line (2 points that could draw a line directly through the middle of the instantaneous point given and find their slope
  + One of these points could be the instantaneous points
  + Well-spaced points work best
  + The answer using this method should be within 10% of the actual answer
* A tangent line can be used to calculate any rate

**Acceleration**

* How much speed is gained within a certain period of time (usually per second or per hour)
* SIMPLE CASE: Change in Velocity ÷ Duration = Acceleration per unit
  + (*vf* - *vi*) ÷ *∆t* = *a*
  + Always measured in speed units and calculated with speed units and time units
* Velocity is a vector, therefore acceleration is also a vector
* If direction of initial and final velocities is not given, assume they are in the same direction
* Negative acceleration means slowing down in the positive direction or speeding up in the negative direction, positive acceleration means speeding up in the positive direction
* Turning Acceleration



* + The two vectors are laid tail to tail, and the distance between their heads is the result of the subtraction of the two vectors
  + The acceleration vector will always point towards the center of the circle
* Ticker Tape Timer
  + Measure the distance between all of the dots and the succeeding dot, and divide by the amount of seconds between each dot (usually 1/60 of a second)
    - *∆t* = the amount of dots between the initial dot being measured and the finial dot being measured x the time interval between each dot
    - *Vf* = the distance between the final two dots ÷ the time interval between each dot
    - *Vi* = the distance between the first two dots ÷ the time interval between each dot
  + Input these measurements into the basic acceleration formula and the result is the acceleration
    - Remember to use the correct units
  + Freefall/Gravitational acceleration = 9.81m/s
    - Often rounded to a simple 10m/s
    - Only in the event of an absence of air resistance
    - True regardless of mass for any object on Earth
      * Gravity is different on other celestial bodies (planets, moons, etc.)

**Kinetic Problem Solving**

* *Requires a One-Dimensional problem and Uniform Acceleration*
* Main equations necessary (in data booklet)
  + *v* = *u* + *at*
    - How fast
      * In some years, this equation has not been in the data booklet (May 2015)
  + *s* = [(*u* + *v*) ÷ 2] x *t*
    - How far (average)
  + *s* = *ut* + ½ *at*2
    - How far (acceleration)
  + *v*2= *u*2+ 2*as*
    - No time equation
* Variables
  + Initial velocity
    - *vi*, *u*, *v*0
  + Final velocity
    - *vf*, *v*
  + Displacement
    - *∆x, s*, *∆d*
  + Typically, IB uses the SUVAT variables (*s* for displacement, *u* for initial velocity, *v* for final velocity, *a* for acceleration, and *t* for time)
* Rearranging these equations
  + Definition of acceleration
    - *a* = (*v* - *u*) ÷ *t*
  + Definition of average velocity
    - *vavg* = *s* ÷ *t*
    - *vavg* = (*u* + *v)* ÷2
    - *s* = [(*u* + *v*) ÷ 2] x *t*
  + Use substitution to figure out that…
    - *s* = *ut* + ½ *at*2
    - *v* = *u*2 + 2*as*
    - Therefore, it makes sense
* Important points for solving problems
  + Believe in yourself
  + Be persistent
  + Listen to your gut feeling
  + Draw a diagram
  + Make lists of the values of your variables and what they mean
  + Use equations as a guide to the underlying physics principles
  + Find the equation that only uses the variables that you have and need to find

**Vertical Projectiles**

* Gaining speed = speeding up
  + Therefore, if an object is increasing in speed at a rate of 20m/s every second, after 3 seconds it will be traveling at 60m/s
* Average speed is initial speed + final speed divided by 2
  + - *(u* + *v*) ÷ 2
    - Therefore, in this example, the average speed is 30m/s
    - In 3 seconds, it will have traveled 90m factoring in that the object is speeding up
* Acceleration = Gravity = 9.81m/s
* Gravitational force = mass x gravity = weight
  + Remember the difference between mass and weight
    - Weight depends on location and is a force
    - Mass depends on the amount of matter
    - For example, a scale tells you your *mass*, not your *weight*
* Newtons = kg x m/s2 for acceleration due to gravity
* Newtons = kg x N/kg for gravitational field strength
* Newtons are weight, kilograms are mass
* Weight = Mass x gravity
* Remember that the point on a velocity-time graph where the line meets the *x*-axis is where the object turns around
* A velocity-time graph would be a diagonal line downwards that intersects the *x*-axis at the turnaround point
* An acceleration-time graph would be a straight horizontal line
* A position-time graph would be a concave parabola opening downwards
* *a* = -*g*
* *v* = -*gt* + *u*
* *s* = *si* + *ut* + ½ *at*2

**Vectors in Component Form**

* 2 possible forms; Polar and Component form
  + Polar form: “5km NW *from here*”
    - Relative to a location
    - [distance, polar angle]
      * ex. (5, 45o)
        + Counter-clockwise from the right horizontal axis line
  + Component form: “8km W and then 7km SE”
    - General directions
    - [*x*, *y*]
      * ex. (-8,+7)
        + Signs symbolize the positive and negative directions
  + Converting between the two is called “resolving a vector”
  + Polar to Component form conversions
    - If you have the hypotenuse and an angle within a triangle, use sin and cos
      * For example:



* NOTE: You can use the given angle too, but if you use the polar angle, the signs will be given automatically once you figure out the numerical values of *x* and *y*
* If you are missing the hypotenuse, use the Pythagorean Theorem to solve for it if the triangle is right-angle
  + *a*2 + *b*2 = *c*2 when *c* = the length of the hypotenuse and *a* and *b* are the lengths of the other two sides
* θ = tan-1(*y* ÷ *x*) (+ 180o if *x* < 0)
* Component to Polar form conversions
  + hyp. = sqrt(*x*2 + *y*2) [distance]
  + θ = tan-1(*y* ÷ *x*)[direction]
    - Remember to add 180o if *x* < 0

**Adding Vectors Using Components**

* Remember which directions cancel out (opposite directions)
  + N and S
  + W and E
  + NE and SW
  + NW and SE
  + For example, if I travel 2km W, 3km N, 4km E, and 3 km S, then my displacement is 2km E from my initial starting point
* [E39oN] means starting East, move 39o North and head that way
* Write in Polar form, then convert to Component form, then add the coordinates (*x*1 + *x*2, *y*1 + *y*2) in Component form, then convert back to Polar form and express the answer in the same form as was stated in the given question

**Vector Subtraction**

* Adding the opposite vector instead of subtracting like with normal numbers
* Join the vectors tail to tail (tail = starting end, one without the arrowhead), the missing line represents the answer
* Opposite vectors
  + Polar form
    - Find the opposite angle
  + Component form
    - Make the signs opposite

**Projectiles**

* Forces acting on a projectile ignoring air resistance
  + Weight (vertical)
  + No horizontal forces
* *s* = ½ *at*2
* Shape of flight is parabolic due to gravity
* Horizontal motion does not affect vertical motion
* Remember to use the above formula to calculate fall distance, where *a* = *g*
  + An item dropping vertically from 10m is the same as an item falling from being thrown horizontally with a peak of 10m
* Maximum height is half of the total time if thrown from the ground
  + ex. throwing a ball from the ground takes 10s to hit the ground again, so maximum height was achieved at 5s, because 5 is half of 10
* Acceleration is always negative
* Gravity always brings projectiles down by the same amount in the same time from the no gravity line
  + No gravity line = the line that an object would travel when being thrown downwards/horizontally if gravity did not pull the object towards the Earth
* Acceleration is 0 in horizontal, -*g* in vertical
* Velocity is always *u* in horizontal, *u* - *gt* in vertical
* Position is always *ut* in horizontal, initial height + *ut* - *gt*2