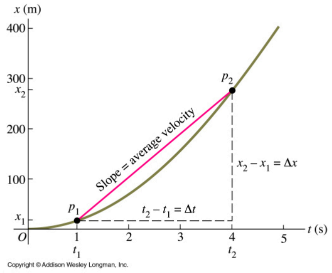
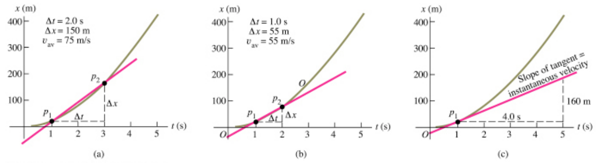
Velocity

- The slope of the line between two points on a **displacement-time** graph gives the **average velocity** between the points



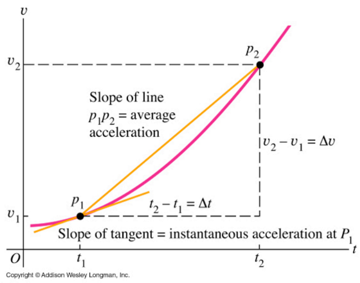
Instantaneous velocity

- How can we get an estimate of the instantaneous velocity?
- Narrow the time (Δt) of the average – geometrically the slope comes closer and closer to the tangent to the curve
- The slope of the tangent at p_1 is the **instantaneous velocity**



Acceleration

- The slope of the line between two points on a **velocity-time** graph gives the **average acceleration** between the points
- The slope of the tangent at p_1 is the **instantaneous acceleration**

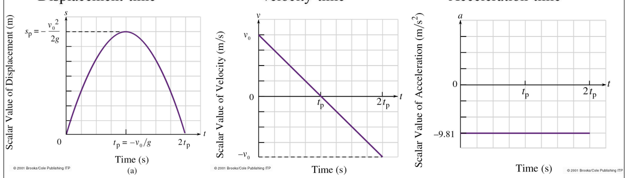


Acceleration due to gravity

- Motion of a ball thrown straight up (at t=0), reaching maximum height (at t=t_p), and falling straight back down again, ending at t=2t_p.

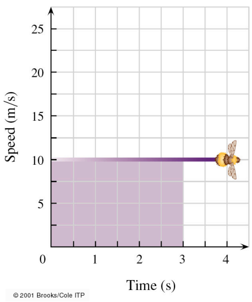
(Upwards is chosen to be positive)

Displacement-time Velocity-time Acceleration-time

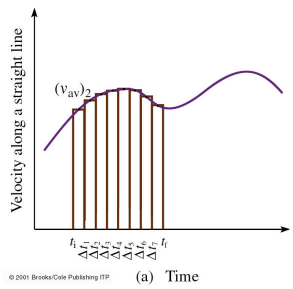


Area under a velocity-time graph

- A horizontal line on a velocity-time graph corresponds to constant velocity
- The area of the rectangle under the line
  = velocity (m/s) × time (s)
  = displacement (in metres)

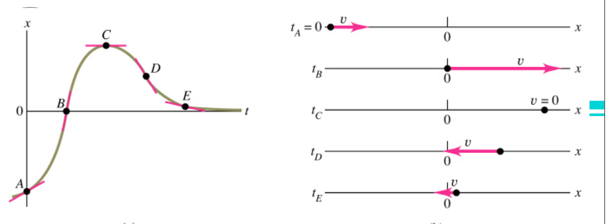


- For a changing velocity, the total area under the curve between t_1 and t_2 (adding all the rectangles) is still the distance travelled (in metres) in that time interval



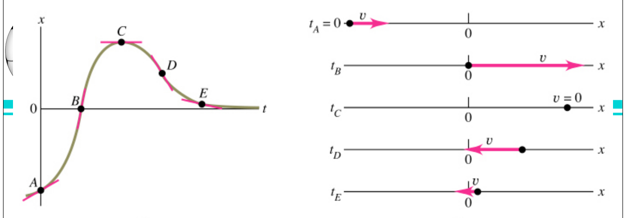
Example

- *Carefully* follow the example outlined on the next few pages. It describes the motion of a runner as plotted on a displacement-time graph. He simply runs in one direction, stops, turns, and runs part of the way back again and stops.
- The first description just considers **displacement and velocity**.
- The graph has no values on the axes, but we can still describe the characteristics of the motion
- Try sketching the velocity graph for the runner's motion



(a) (b)

- (a) displacement-time diagram of a runner
- (b) a motion diagram showing the position and velocity at A,B,C,D,E
  - Between A and B, the runner's position (x) is negative but increasing. The slope is becoming steeper so the runner is moving with increasing velocity in the positive x direction.
  - At B the slope (i.e. velocity) is greatest.
  - Between B and C the runner is still moving in the positive x direction, but the slope (velocity) is decreasing.



(a) (b)

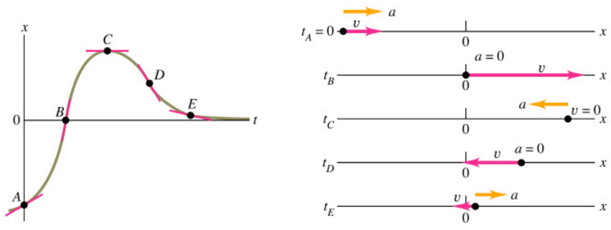
- At point C the slope (velocity) is zero for a moment as the runner stops and turns around.
- From C to E, x is positive but decreasing, so the runner's velocity is negative.
- The most negative velocity value occurs at D, where the slope is steepest (most negative).
- At point E the slope (velocity) are approaching zero as x approaches a constant value - i.e. the runner is coming to a stop.

The second description considers **displacement, velocity *and* acceleration.**

You will probably find this harder.

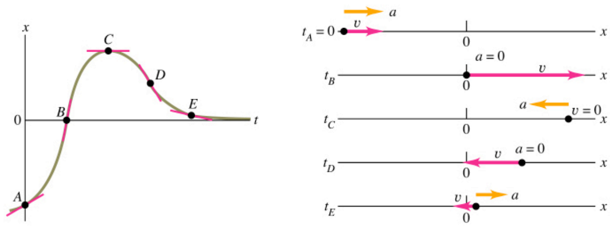
Think about it carefully.

Try sketching the acceleration graph for the runner's motion.



(a) (b)

- (a) the *same* displacement-time diagram of a runner
- (b) a motion diagram showing the position, velocity *and acceleration* at A,B,C,D,E
  - Between A and B, the slope is becoming steeper (the graph is curved upward) so the runner is moving with increasing velocity in the positive x direction. His acceleration is positive.
  - At B the slope (i.e. velocity) is greatest, but the acceleration is momentarily zero.



(a) (b)

- From B to D the runner's acceleration is negative and his velocity is decreasing from a positive value at B, to zero at C, and to a negative value at D.
- From D to E, the graph is once again curved upward. The velocity is negative but approaching zero, so the acceleration is positive.