1. Let's make a *plan* for solving a typical acceleration problem like this: ***"A rock is tossed straight up with a certain given velocity. How high will it be after a certain number of seconds?"***
   a. Begin by sketching its velocity vs time graph. Label a point on the velocity axis to represent the given initial velocity. Also label the given point on the time axis. (It's *unlikely* to be the special time where the line crosses the axis, so pick a spot somewhere to the left of that point.)
   b. Draw a vertical line up from that spot to intersect the diagonal graph line.
   c. Shade in the trapezoidal region to the left of that line.
   d. According to #2 on RS II, the area of that trapezoid is equivalent to the rock's _____________, which is usually represented by the letter ___. In what SI units do we measure that quantity? ___
   e. Write the simplest formula for that area. It must contain a letter representing acceleration and the three other letters defined above, but *no other letters*. (See page 27 or #7 on page 24.)
   f. Eq. 1e describes the rock's __________ vs _____ graph. The process we used is called "*integration*".

2. Use equation 1e to make a data table and a graph of the rock's **displacement vs time**. Use an initial velocity of **20 m/s upward** and a time range from **0 to 4 seconds**. For simplicity, pretend that the gravitational acceleration is **10 m/s^2**, instead of 9.8 m/s^2. Let your graph have about 8 to 10 points. Make it fill about half a sheet of graph paper. You may use a graphing calculator if you prefer.

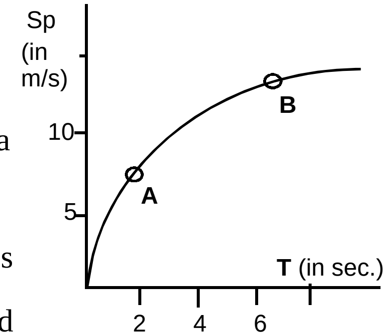
3. Using the other half of the graph paper, make an accurate version of the **velocity-time** graph that you sketched in 1a. Use the starting point and slope that were given in #2. Velocity is *not* distance ÷ time!
   a. Write an equation describing that graph as we did in 7c on p. 24, and in #3 on p. 26: __ = ______
   b. Somewhere between the origin and the midpoint of the time axis, mark two points at least half a second apart. Label them "T_1" and "T_2". **(T_1 = ___ sec., T_2 = ___ sec.)**
   c. Draw vertical lines through those two points to intersect the diagonal line.
   Count the little squares in the trapezoidal area between them: [_____ squares]
   d. Calculate the area of one little square by multiplying its height (in m/s) by its width (in seconds):
   Area of One Square = (____ ___)(____ ____) = _____ ____
   e. Multiply the number of squares in 3c by the area of one square: **Trapezoid area = _____ ___**
   f. The process used to determine that area is called "__________tion". (Copy from RS II.)

4. Label the *same* two points on the T axis of the D-T graph in #2. **(T_1 = ___ ___; T_2 = ___ ___)**
   a. Draw vertical lines up from those two points to intersect the curve.
   b. Draw horizontal lines from those two intersection points to intersect the "D" axis.
   c. Label the two intersection points on the D axis as "D_1" and "D_2". Using 1e, determine their numerical values as precisely as you can: **D_1 = ____ ___** **D_2 = ____ ____**.
   d. How is the trapezoid area in 3e *related* to the two displacements in 4c? **Trapezoid area** = ______
   Does 4d agree with 3e? ___ This discovery is already recorded in #___ on RS II.

5. Draw a straight line connecting the two points which you marked on the curve in 4a. Then use the ΔD and ΔT found above to calculate the slope of that "chord": (___ ___) ÷ (___ __) = ______ _____.
   a. That slope is equal to the ________ speed of the object during the time interval between ____ and ____ sec. (Copy the adjective from RS I.) Use the linear equation in 3a to find out what *time* it was when the object's speed was equal to that slope. Then use the graph to check. ______ ____
   b. That "*special time*" must be a point on the ____ axis. Label it clearly on *both* graphs.

6. The object's "instantaneous velocity" is the slope of a **tangent** line on its displacement vs time graph. Its "average velocity" is the slope of a **chord**, as in 5a. In 5b we found that there is a "special moment" in the time interval when the object's instantaneous velocity is *equal* to its average velocity. In 5b the special tangent line is ________ to the chord. *Illustrate* that relation with another sketch. Draw a vertical line from the point of tangency down to the T axis, and label the "special moment" on that axis.

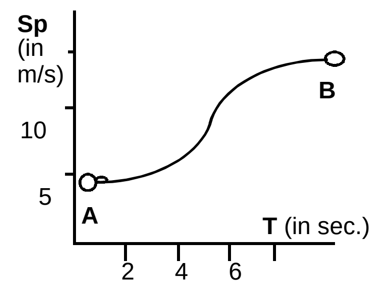
7. In #5 the displacement-time graph was a special type of curve called a _______. The "special moment" in #5 turned out to be precisely at the ____point of the time interval. To find out if that was just a coincidence, draw a big new graph as a *circular* arc in the first quadrant with its center at the origin. Let T_1 be the origin and let T_2 be the point where the arc intersects the time axis.
   a. Draw a chord (as in #5 & 6) draw a tangent line parallel to it, and label the special moment *as in 5b*.
   b. Is the special moment located at the midpoint of the interval in *this* example? ___
   c. The "special moment" is located at the midpoint of the time interval *only* if the curve is a ________.
   d. Does 7c contradict 7b? ___ -Does #5 above agree with 4c on page 23? ___



1. The speed-time graph at the right describes an object's motion. Use it to fill in the blanks below:
   a. Point "A" on the curve has coordinates T_a = ___ __ and S_a = ___ ___.
   b. Point "B" is at T_b = ___ ___ and S_b = ___ ____.
   c. Those times have uncertainties (SDC's) of roughly one ____th of a division, or roughly ± _____ ____.
   d. The speeds have uncertainties of roughly ± ____ ____. (See page 1.)

2. Draw a straight line tangent to the curve at point A. The object's "instantaneous acceleration" at time T_a is the *slope* of that tangent line.
   a. Determine that instantaneous acceleration as precisely as you can, and *show how you do it*. Don't forget the units.
   * b. Explain what is meant by the object's instantaneous acceleration at T_b.
   * c. Show that you understand 2b by calculating the value of that acceleration as accurately as you can, with units. (Label the two points that you use as "C" and "D".)
   * d. Estimate the relative uncertainty of 2c and show how your estimate is made. (Use #26 on RS II.)
   e. If C and D were half as far apart that percentage would be __ times as big. Would that be good?

3. The object's "initial acceleration" is the instantaneous acceleration which it had at the beginning of the interval, at time T_a. Its "final acceleration" for that interval is its instantaneous acceleration at the end of the interval, at time T_b. The object's "average acceleration" for that time interval is defined as the **slope** of a **chord** connecting points A and B. Please *draw and label* that chord on the graph above.
   a. Is the average acceleration during this time interval equal to the initial acceleration? ___ --Is it equal to the final acceleration? ____
   b. Now look at the graph ***at the right***. In this example the slope of the tangent line at T_a is zero, and the slope of the tangent line at T_b is ____.
   c. The arithmetic mean of the initial and final accelerations in 3b is about ____ ____, but the average acceleration is roughly ____ ____.
   d. An object's average acceleration is __________ equal to the arithmetic mean of its initial and final accelerations. (always, sometimes, never)
   e. Does 3d contradict 3c? ___ Does 3d contradict #2? ____



4. A curve is "smooth" if it has no corners or gaps. Suppose we have a smoothly curved speed-time graph with points A and B marked on it, like either of the graphs sketched above. For every point on the arc AB one can imagine a tangent line. Each imaginary tangent line has a slope.
   a. Must one of those tangent lines have the same slope as chord AB? ___ If not, then please sketch a smooth curve for which there is *no* point with a tangent-line-slope equal to the chord-slope.
   b. If the special tangent line mentioned in 4a does exist, let "P" represent the point where it touches the curve. According to #3, the **instantaneous acceleration at time T_p** must be equal to the ______ acceleration during the interval between time ___ and time ___.
   c. Must the special time called "T_p" be at the midpoint of that interval? ___
   d. Which of the graphs above best illustrates the answer to 4c? (#1, or #3?) ____
   e. On page 28 you discovered that T_p ***is*** at the midpoint of the interval between T_a and T_b ***only*** if the graph is segment of a _________ curve. Which graph above best illustrates that answer?___

5. Suppose we are limited to graphs which resemble a circular or parabolic arc between points A and B and which have only *slight curvature* in that interval. (Almost any kind of curve satisfies those conditions if we make the interval short enough.) In *that* case the "special" point that was mentioned in 4b & 4c is near the _______ of the time interval. (beginning, middle, end) Please illustrate this discovery by sketching a graph with a chord and a tangent line. *Label times T_a, T_b, and T_p clearly on the time axis of that sketched graph.*

6. Sketch a graph of the equation $D = at^2/2$. Draw a straight line from the origin to another point on the curve. The slope of that "chord" is the object's ________ ______ for the part of the trip between the origin and the other chosen point. Next, draw a tangent line at the same chosen point. The slope of that tangent line is the ________ _______ at the chosen point. How do those slopes compare?

Tangent slope = (__)(chord slope), because the exponent in this equation is ___.