Kinematics Problems
(Algebraic Manipulation)

1. A turtle is racing a bunny a distance d. The turtle has a constant velocity of v. The bunny waits until the turtle is 2 m from the finish line and then accelerates from rest through the entire distance d. Show that for the bunny to win the race its acceleration must be greater than $\dfrac{dv^2}{2}$.

2. You are standing on an overpass that is a height h above traffic. You see a truck traveling towards you with constant velocity v. You jump from the overpass with the intent of landing on the truck. How far away from the overpass must the truck be when you jump for you to land on it?

3. A ball is dropped from a height h above the ground. What is the velocity of the ball when it is at a height of y above the ground?

4. Rock A is dropped from a height h. Rock B is thrown from the same height h with a velocity v downwards. Both rocks hit the ground. Show that

   (a) rock A hits the ground in a time of $\sqrt{\dfrac{2h}{g}}$

   (b) rock B hits the ground in a time of $\dfrac{-v + \sqrt{v^2 + 2gh}}{g}$

5. Two race cars are beside each other traveling with constant velocity v. When the finish line is a distance d away one of the cars accelerates at a rate of a (while the velocity of the other car remains constant) and finishes the race t seconds before the other car. Show that

$$a = \frac{2v^3 t}{(d - vt)^2}$$

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