

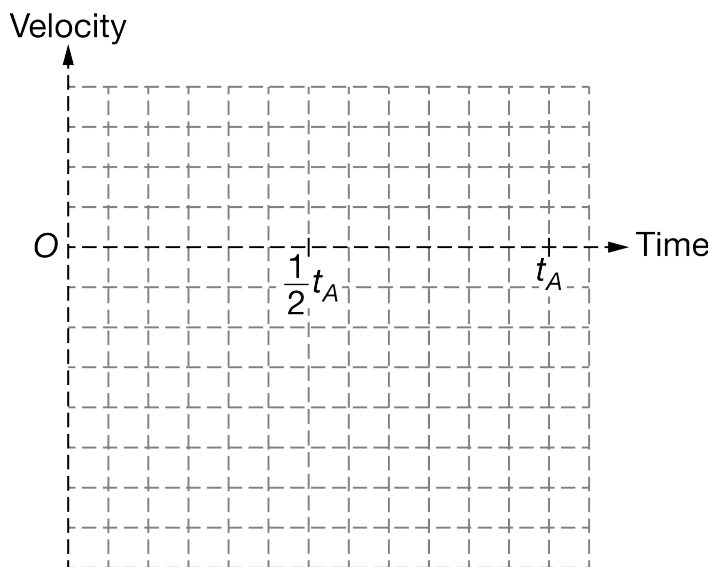
**Free Response Kinematics 3**

1. This question is a short free-response question. Show your work for each part of the question.

(7 points, suggested time 13 minutes)

In an experiment two identical rocks are simultaneously thrown from the edge of a cliff a distance  $h_0$  above the ground. Rock A is thrown vertically upward with speed  $v_0$  and rock B is thrown vertically downward with speed  $v_0$ . Rock A and rock B strike the ground at times  $t_A$  and  $t_B$ , respectively. Consider the positive vertical direction to be upward.

- (a) On the axes given below, sketch and label graphs of the velocity as a function of time for rock A and rock B. Label the time  $t_B$ . Times  $t_A$  and  $\frac{1}{2}t_A$  are given on the graph.



- (b) Rock B hits the ground at time  $t_B$ . Derive an equation for the time  $t_A$  it takes rock A to hit the ground in terms of  $v_0$ ,  $t_B$ , and physical constants, as appropriate.