1. A Civil War cannon is located on a low plain; there is a high cliff at the edge of the plain (the distance from cannon to cliff is larger than the cliff height). A cannonball is fired so that it is coming down when it lands somewhere atop the cliff.
a. Show the cannonball's motion from the instant it leaves the cannon until the instant before it hits the ground. Draw a complete motion diagram with labeled velocity and acceleration vectors. Show the horizontal and vertical components of velocity. Try to have at least 7 dots, with one of the dots located at the high point of the trajectory.
b. In your motion diagram, suppose the launch speed $v_{0}$, the cliff height $h$, and the time of flight $\Delta t$ are known. All other parameters of the flight, such as the launch angle $\theta$, are unknown. Write the velocity $\left(v_{y}(t)\right)$ and position $(y(t))$ equations for the vertical motion and the position equation $(x(t))$ for the horizontal motion. Then write a strategy for finding launch angle, maximum altitude, and range of flight (horizontal distance from launch to landing).
2. Below are three possible motion diagrams for a particle. For each case, draw and label an arrow to represent the net force at time 2. Are the time labels important for the directions of your arrows?

3. Consider the motion diagram below; it could be the motion diagram for one swing of a ball on a string (a pendulum). At times 0 and 4 the particle is momentarily at rest. Draw and label the net force arrow at each of the five points. Explain how you decided on the direction of the net force arrow for each time. HINT: you must write about how the velocity (both speed and direction) is changing at each dot.
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4. For the motion diagram in 2(a) you are now given that the mass of the particle is 1.5 kg and that the acceleration is $3.0 \mathrm{~m} / \mathrm{s}^{2}$ rightwards. You are also given that there are only two forces acting on the particle, and that one of those two forces has a magnitude of 15 N and points towards the bottom of the page. Find the second force acting on the particle, magnitude and direction (relative to rightwards on the page).
