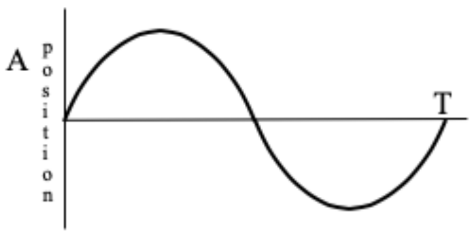
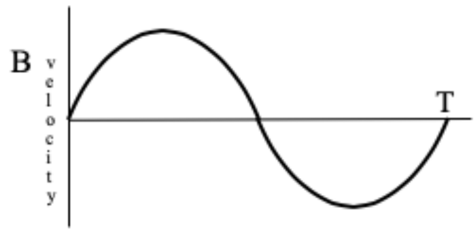
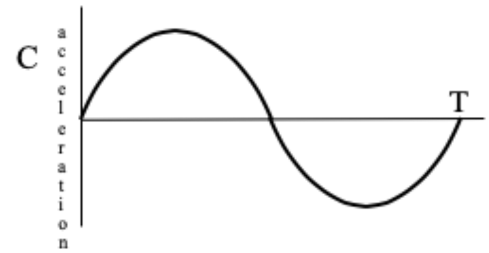
From Frensley #1: Object's A, B and C all start at the same position and move along parallel lines. The graphs below represent the motion of the objects during the interval 0 < t < T. Note the labels on the vertical axis of each graph (the first is position, the second velocity and the third acceleration, if the print is too small to read), and assume that C starts from rest.







a.) Rank the displacement of the three objects for the interval 0 < t < T from least to greatest. Explain your reasoning.

Taking the motion of each graph separately:

--graph A is Position vs Time: It shows an object that starts at some point and ends up back at that same point. It's net displacement is zero;
--graph B is Velocity vs Time:
--the area under that graph gives the net displacement;
--during the first half of the motion, it moves through some positive displacement (the area under that portion of the graph is positive);
--during the second half of the motion, it moves through a negative displacement that, due to symmetry, is equal to the amount moved during the first half;
--conclusion, the net displacement is zero;
--graph C is Acceleration vs Time with the initial velocity being zero (the best way to look at this --graph is in quarters, or time intervals T/4);
--during the first half of the cycle, the body's acceleration is positive;
--during the first quarter, the velocity change is positive and increasing
--during the second quarter, the velocity change is still positive but the size of the increase is getting smaller and smaller as time proceeds;
--by T/2, the body is moving with some positive velocity v, and will have moves some net distance d;
--during the third quarter, the velocity will be positive but the acceleration will now be negative, which means the body will begin to slow down—that does NOT mean it will reverse direction;
--during the third quarter, the velocity change will make the body slow at a faster and faster pace;
--during the fourth quarter, the velocity change will continue to make the body slow, but at an every slowing pace'
--throughout the entire second half, the body will have continued to move in the same direction it was moving to start, having come back down to zero velocity by T but having gone a distant 2d;
--so to answer the question, the least displacement will be shared by graphs A and B and the most will be graph C.

b.) Rank the number of times the three objects change direction between but not including the endpoint times of the 0 < t < T interval (do this from least to most). Explain your reasoning.

--for the Position vs Time graph A: turnaround points on Positive vs Time graphs happen at inflection points (i.e., where the position is getting larger, for instance, and then it's getting smaller . . . this, by the way, happens where the slope of the graph is zero) . . . so for this graph, the body turns around twice;

--for the Velocity vs Time graph B: turnaround points on Velocity vs Time graphs happen when the velocity crosses the x-axis and the velocity is zero (i.e., a turnaround necessitates going from a positive to negative velocity or vice versa); this graph does that once ;

--for an Acceleration vs Time graph: turnaround points on Acceleration vs Time is not immediately evident; its slope is not related to the velocity, it's related to the *change* of velocity, so to answer the question you have to go through the same thinking we went through in Part a, which concluded that the motion is in one direction only and there are no turnaround points.

--so to answer the question, from least to most, the turnaround points are: C, B, A