1. The diagram shown below depicts a region of space containing a positive point charge +*Qo* that is fixed in place. The dashed curves in the diagram indicate positions of *equal potential energy.*



Three locations *(A, B,* and *C)* are labeled. Locations *B* and *C* are the same distance from the point charge *Qo.*

### A. At each of the labeled locations *(A, B,* and *C),* draw an arrow to indicate the direction of the force exerted on a positive test charge +*q*test placed at that location.

B. Rank the locations *A, B,* and *C* according to the magnitude of the force that would be exerted on the test charge +*q*test at those locations, from greatest to smallest. Explain your reasoning.

### C. Suppose that two identical, negatively-charged particles are launched (one at a time) from location *C* with initial speed *vo.* One of the particles passes through point *A;* the other passes through point *B.*

Which particle, if any, will have the *greater speed* upon passing the later labeled point? Explain how you can tell.

2. The diagram shown depicts a region of space. The dashed curves indicate positions of *equal potential energy.* Three locations *(X, Y,* and *Z)* are labeled.



All parts of this problem refer to a particle that is launched from point *2* and later passes through point *3.* The particle is observed to move with *decreasing speed* from point *2* to point *3* *(i.e.,* *v2* > *v3).*

A. Rank the locations *X, Y,* and *Z* according to the potential energy that the particle would have if it were   
placed at that location. Explain your reasoning.

B. Rank the locations *X, Y,* and *Z* according to the magnitude of the force exerted on the particle if it were placed at that location. Explain your reasoning.

C. At each of the labeled locations in the diagram, draw an arrow to indicate the direction of the force exerted on the particle if it were placed at that location. Explain your reasoning.

D. Part of the above diagram is reproduced at right. Three vectors originating from point *Y* are also shown. The middle vector points directly from point *Y* to point *Z.*



In order for the particle to be launched from *Y* and reach *Z,* which vector best represents the initial velocity of the particle? Clearly indicate your choice and explain your reasoning.

3. The diagram at right depicts a region of space in which a conservative force  can act.



Three identical particles are located at the labeled locations *(1, 2,* and *3).* Each vector represents the force exerted on the particle at that location. The magnitudes of the forces rank as follows: *F3* > *F2* > *F1.*

A. In the space above, carefully sketch an equipotential diagram that could be used to represent the potential energy *V(x, y)* in the region shown. Make sure your equipotential lines are consistent with the force vectors already drawn. In the space below, explain the reasoning you used to make your sketch.

B. On the basis of your results in part A, rank the labeled locations *1, 2,* and *3* according to the potential energy of the particle at that location, from greatest to smallest. Explain how you can tell.