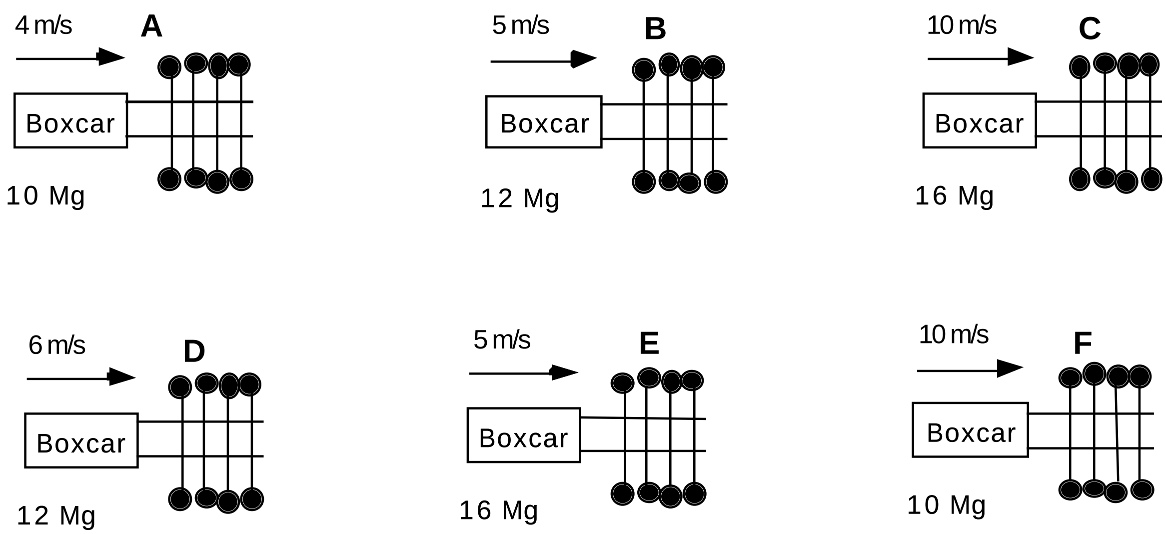
Boxcars and Ropes—Stopping Force in Same Distance [56]

In a western movie, a confederate raiding party stopped a runaway boxcar carrying gold by using many ropes tied to trees. Given below are six boxcars that are moving along horizontal railroads at specified speeds. Also given are the masses of the boxcars. All of the boxcars are the same size and shape, but they are carrying loads with different masses. All of these boxcars are going to be stopped by plowing through a large number of these secured ropes. All of the boxcars need to be stopped in the same distance.

Rank these situations from greatest to least on the basis of the strength of the forces that will be needed to stop the boxcars in the same distance. That is, put first the boxcar on which the strongest force will have to be applied to stop it in *x* meters, and put last the boxcar on which the weakest force will be applied to stop the boxcar in the same distance.



Greatest 1 _______ 2 _______ 3 _______ 4 _______ 5 _______ 6 _______ Least

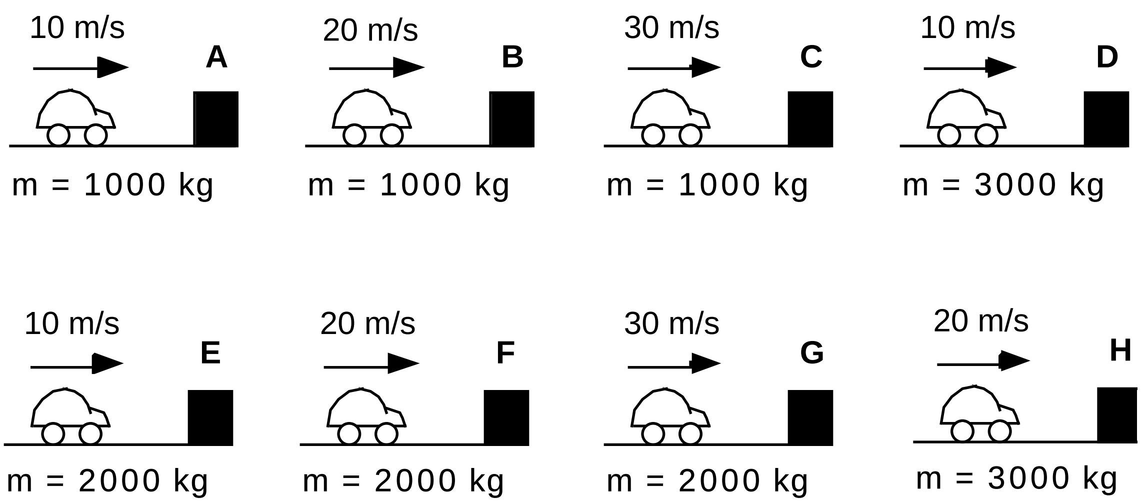
Or, all boxcars require the same force. __________

Please carefully explain your reasoning.

Cars and Barriers—Stopping Distance with the Same Force[58]

Shown below are eight cars that are moving along horizontal roads at specified speeds. Also given are the masses of the cars. All of the cars are the same size and shape, but they are carrying loads with different masses. All of these cars are going to be stopped by plowing into identical barriers. All of the cars are going to be stopped by the same constant force by the barrier.

Rank these situations from greatest to least on the basis of the stopping distance that will be needed to stop the cars with the same force. That is, put first the car that requires the longest stopping distance and put last the car that requires the shortest distance to stop the car with the same force.



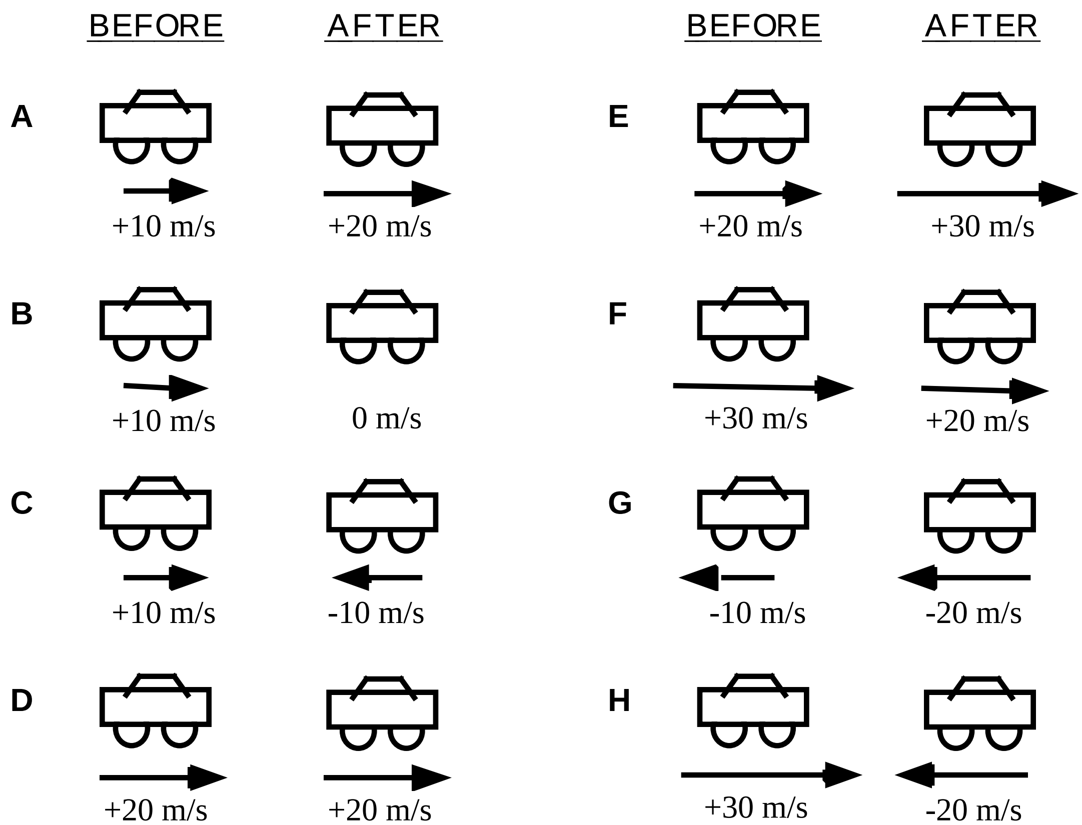
Longest 1 _____ 2 _____ 3 _____ 4 _____ 5 _____ 6 _____ 7 _____ 8 _____ Shortest

Or, all the cars require the same distance. __________

Please carefully explain your reasoning.

Cars—Work Done in Change of Velocity [59]

The eight situations below show *before* and *after* "snapshots" of a car's velocity. Rank these situations, in terms of work done on the car, from most positive to most negative, to create these changes in velocity for the same distance traveled. All cars have the same mass. Negative numbers, if any, rank lower than positive ones (-20 m/s < -10 m/s < 0< 5).



Most Positive 1_____ 2_____ 3_____ 4_____ 5_____ 6_____ 7_____ 8_____ Most Negative

Or, the work done on the cars is the same (but not zero) for all of these. _________

Or, the work done on the cars is zero for all of these. _________

Or, it is not possible to determine the work done on the cars for all these cases. _________

Please carefully explain your reasoning.

Bouncing Cart—Change in Kinetic Energy [60]

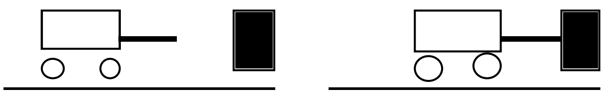
A cart with a spring plunger runs into a fixed barrier. The mass of the cart, its velocity just before impact with the barrier, and its velocity right after collision are given in each figure.

Rank the change in kinetic energy for each cart from the greatest change in kinetic energy to the least change in kinetic energy (+ direction is to the right and - to the left, with –4 < -2).

Before After Before After

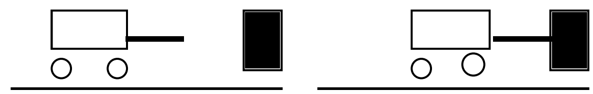
A

Before: 10 kg, v_o = 4 m/s — After: 10 kg, v_f = 0 m/s



D

Before: 20 kg, v_o = 2 m/s — After: 20 kg, v_f = 0 m/s



B

Before: 10 kg, v_o = 3 m/s — After: 10 kg, v_f = -1 m/s

E

Before: 20 kg, v_o = 1 m/s — After: 20 kg, v_f = -1 m/s

C

Before: 5 kg, v_o = 5 m/s — After: 5 kg, v_f = -3 m/s

F

Before: 10 kg, v_o = 2 m/s — After: 10 kg, v_f = -2 m/s

Greatest 1_______ 2________ 3________ 4________ 5________ 6________ Least

Or, all the changes in kinetic energy are the same.____________

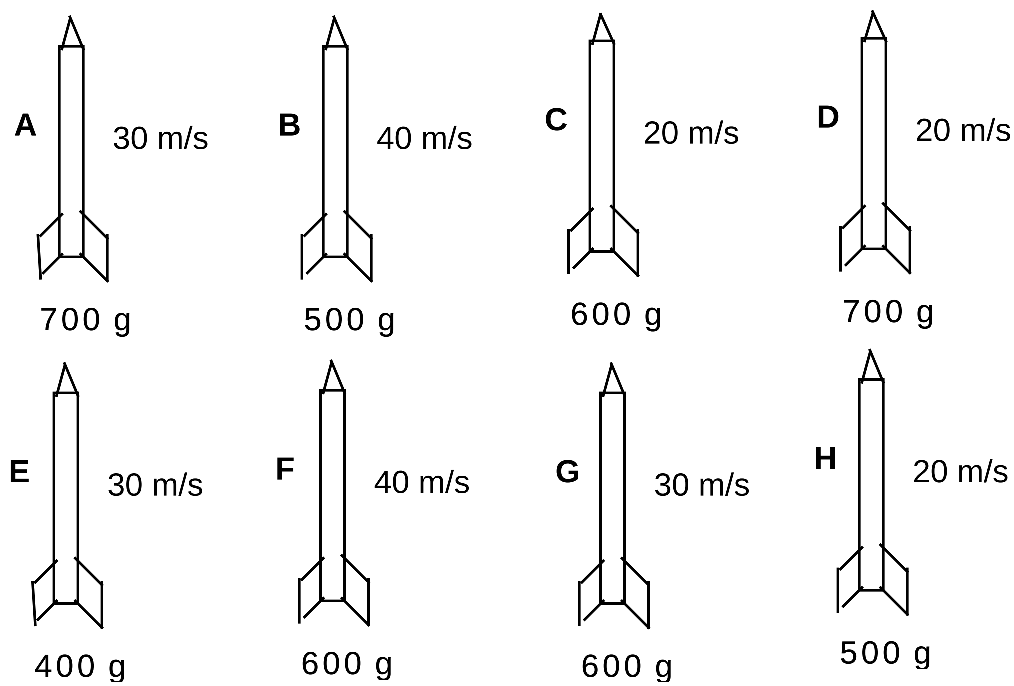
Or, there is no change in kinetic energy for all these cases.___________

Please carefully explain your reasoning.

Model Rockets—Kinetic Energy [63]

The eight figures below depict eight model rockets that have just had their engines turned off. All of the rockets are aimed straight up, but their speeds differ. All of the rockets are the same size and shape, but they carry different loads, so their masses differ. The mass and speed for each rocket is given in each figure. (In this situation we are going to ignore any effect air resistance may have on the rockets.) At the instant when the engines are turned off, the rockets are all at the same height.

Rank these model rockets from greatest to least on the basis of the kinetic energy they have at the top of their flights.



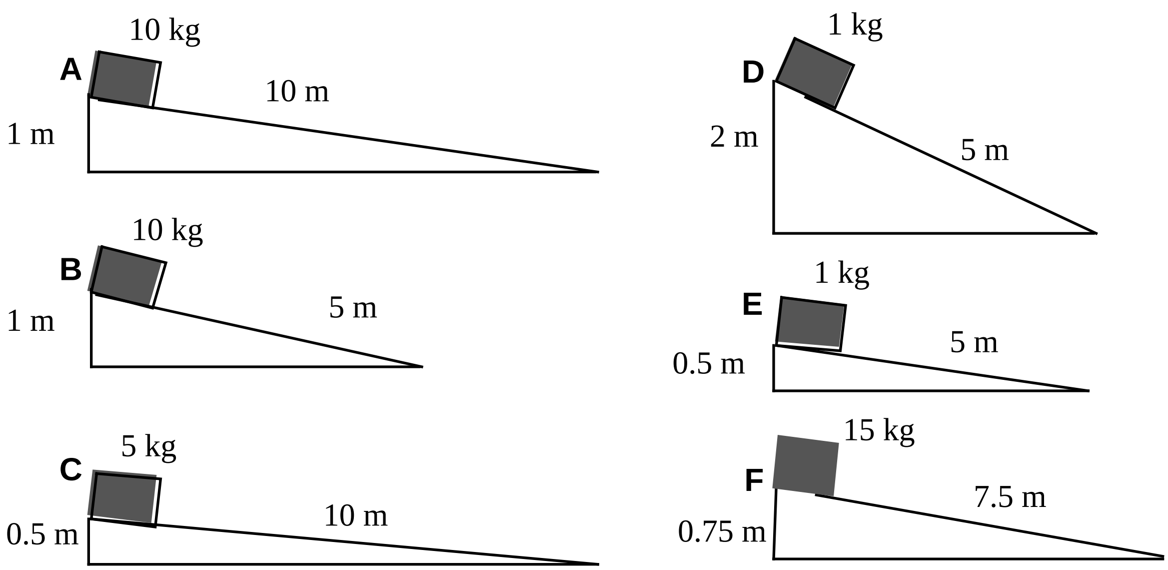
Greatest 1_____ 2_____ 3_____ 4_____ 5_____ 6_____ 7_____ 8______ Least

Or, all rockets have the same kinetic energy.__________

Please carefully explain your reasoning.

Sliding Masses on Incline—Kinetic Energy [64]

Rank, in order from greatest to least, the final kinetic energies of the sliding masses the instant before they reach the bottom of the incline. All surfaces are frictionless. All masses start from rest.



Greatest 1 _______ 2 _______ 3 _______ 4 _______ 5 _______ 6 _______ Least

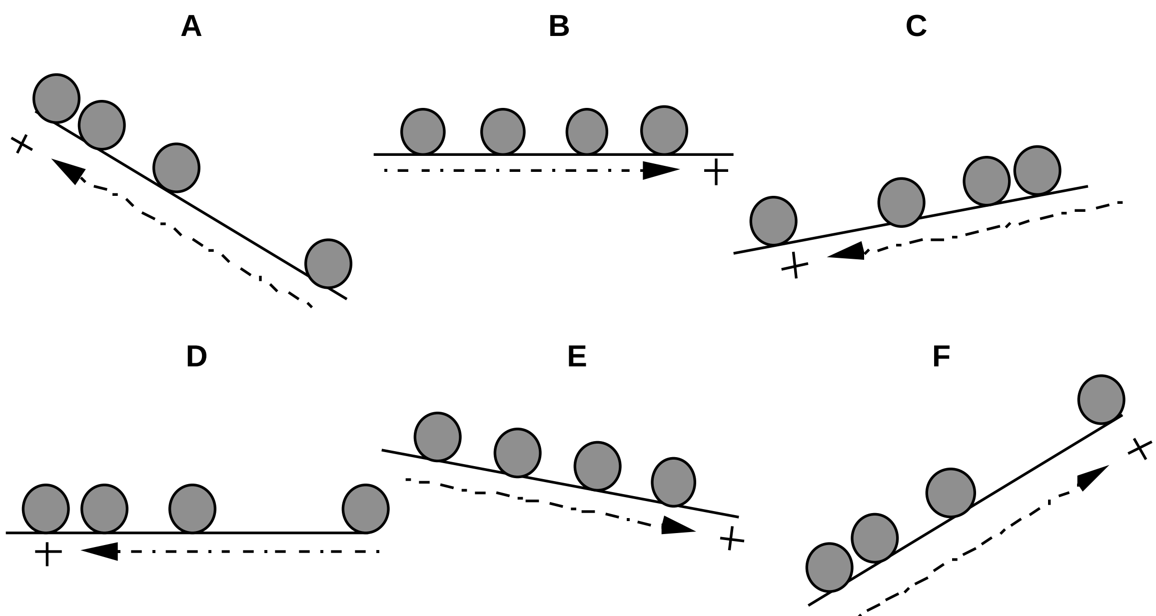
Or, all masses will have the same kinetic energies. ___________

Please carefully explain your reasoning.

Ball Motion Diagram—Kinetic Energy [67]

The following drawings indicate the motion of a ball subject to one or more forces on various surfaces from left to right. Each circle represents the position of the ball at succeeding instants of time. Each time-interval between positions is equal. In all situations, the balls start with the same velocity.

Rank each case from the highest to the lowest final kinetic energy based on the figures using the coordinate system shown in the diagram. Assume the acceleration for each situation to be constant.



Highest 1________ 2________ 3________ 4________ 5________ 6________ Lowest

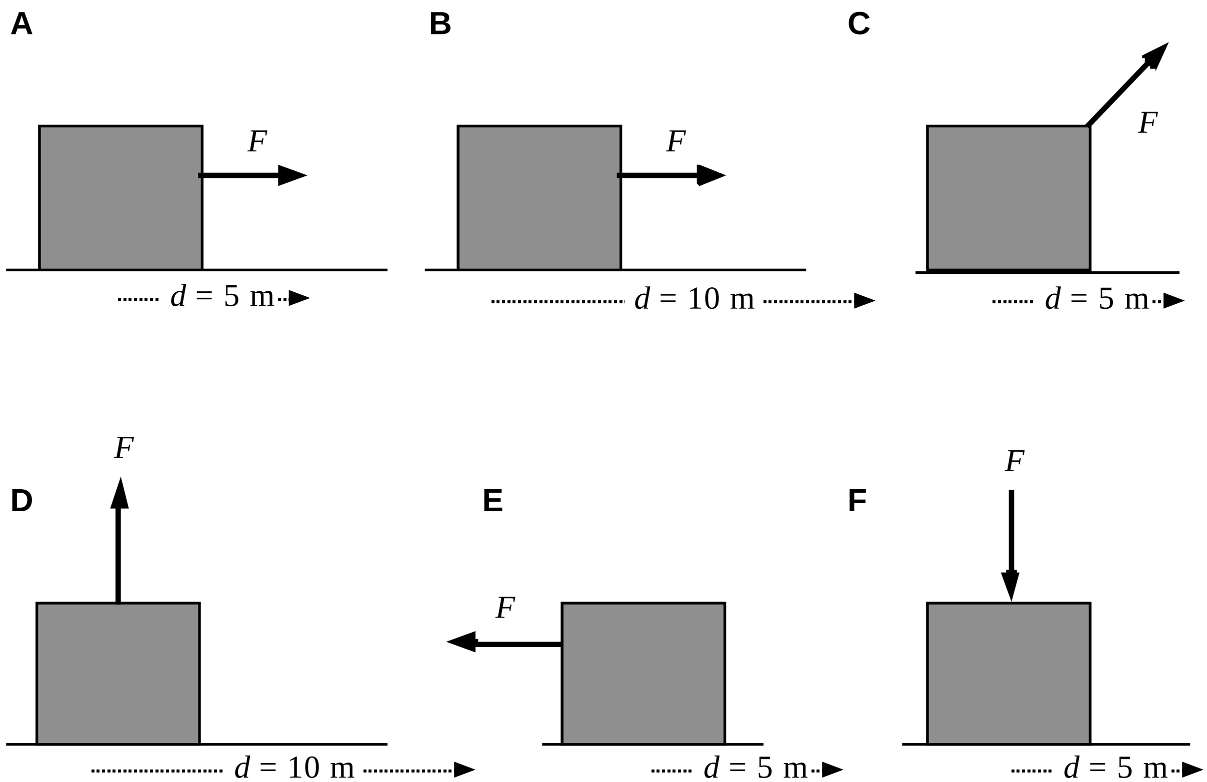
Or, all have the same final kinetic energy._________

Please carefully explain your reasoning.

Equal Forces on Boxes—Work Done on Box [68]

In the figures below, identical boxes of mass 10 kg are moving at the same initial velocity to the right on a flat surface. The same magnitude force, *F*, is applied to each box for the distance, *d*, indicated in the figures.

Rank these situations in order of the work done on the box by *F* while the box moves the indicated distance to the right.



Greatest 1_______ 2________ 3________ 4________ 5________ 6________ Least

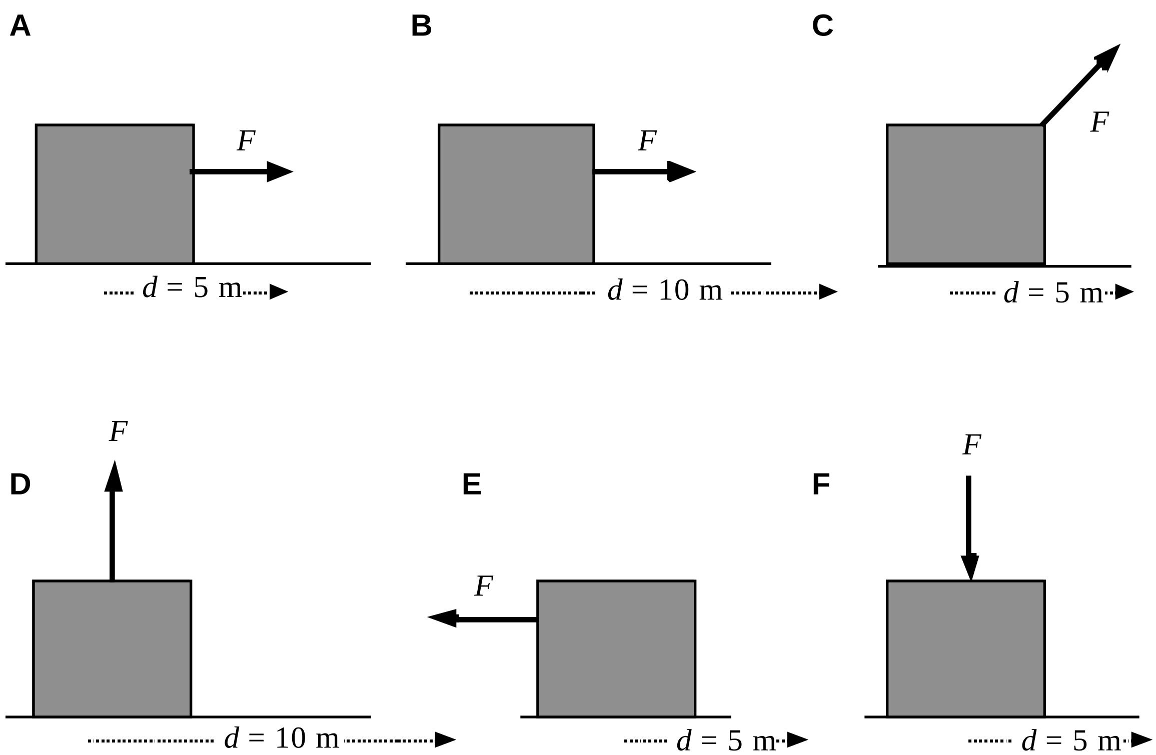
Or, all of the boxes experience the same work. _______

Please carefully explain your reasoning.

Equal Force on Boxes—Work Done on Hand [69]

In the figures below, identical boxes of mass 10 kg are moving at the same initial velocity to the right on a flat surface. The same magnitude force, *F*, is applied by a hand to each box for the distance, *d*, indicated in the figures.

Rank these situations in order of the work done by the box on the hand causing *F* while the box moves the indicated distance to the right.



Greatest 1________ 2_________ 3_________ 4_________ 5_________ 6_________ Least

Or, all of the boxes do the same (nonzero) work on the hand. ________

Or, all of the boxes do no work on the hand. ________

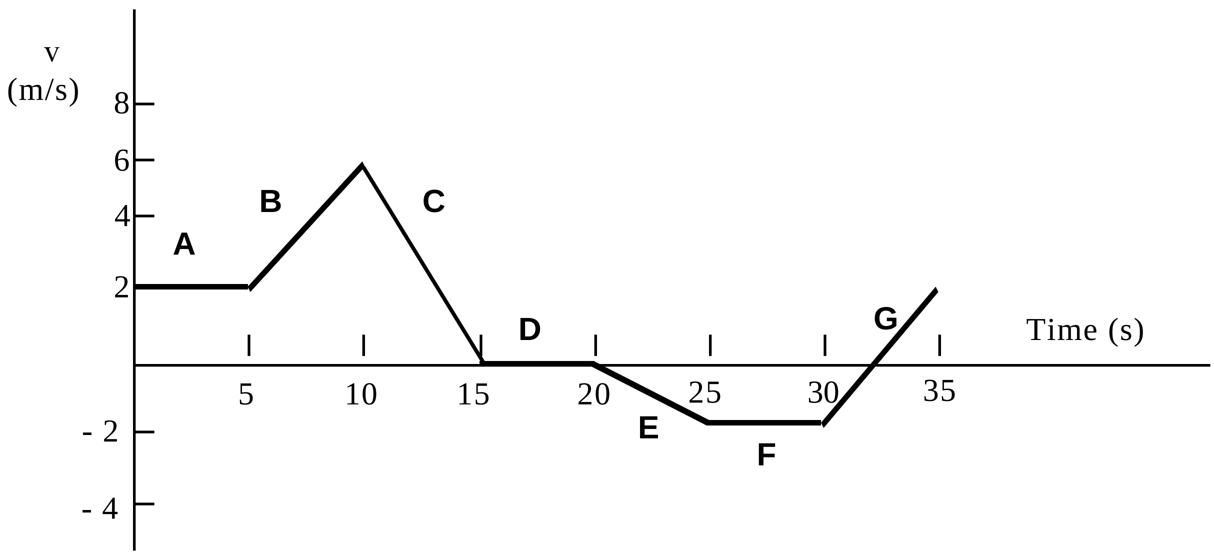
Or, it is not possible to determine the work done on the hand. ________

Please carefully explain your reasoning.

Velocity Time Graph—Work Done on Box [70]

Shown below is a graph of velocity versus time for an object that moves along a straight, horizontal line under the, perhaps intermittent, action of a single force exerted by an external agent.

Rank the intervals shown on the graph, from greatest to least, on the basis of the work done on the object by the external agent.



Greatest 1_______ 2_______ 3_______ 4_______ 5_______ 6______ 7 ____ Least

Or, the agent does the same amount of work during all of these intervals. _________

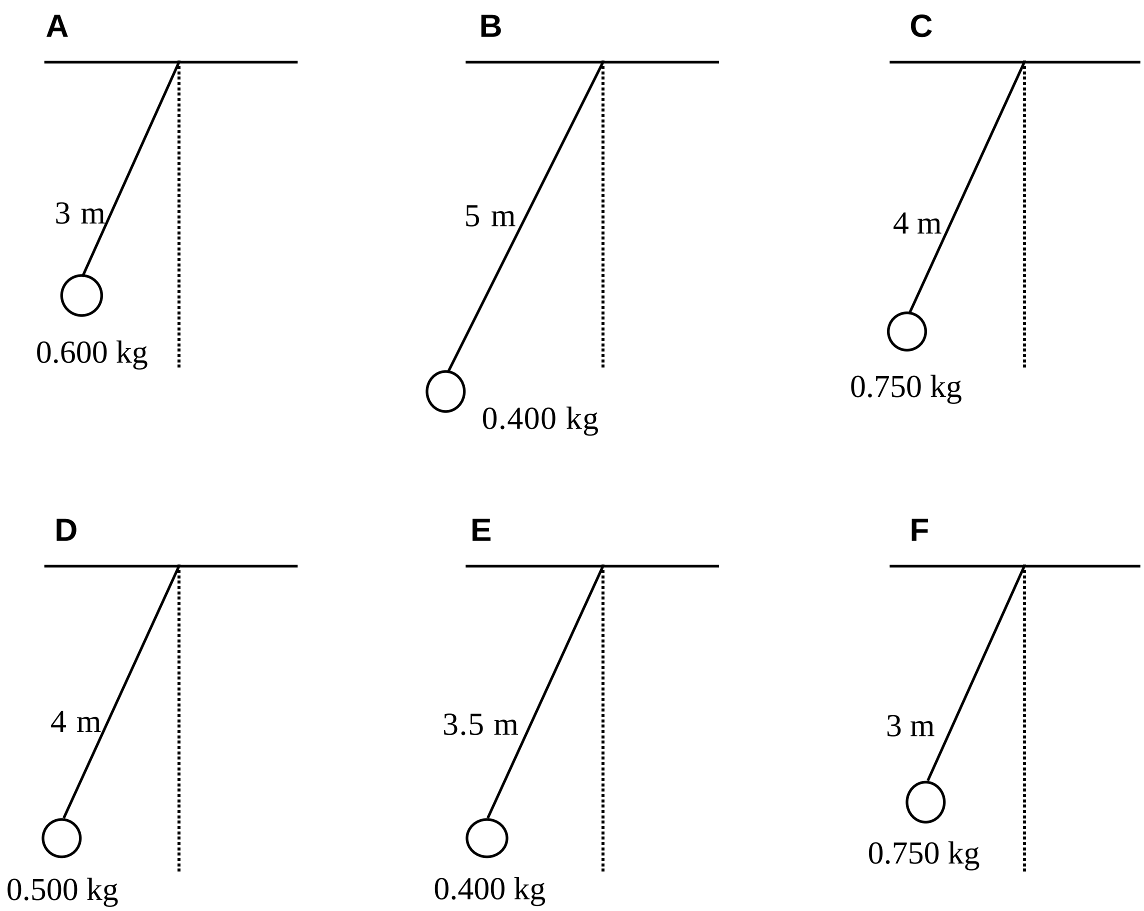
Or, the agent does not work during any of these intervals. ________________

Please carefully explain your reasoning.

Pendulums—Maximum Speed of the Bob[71]

Shown below are six situations where spheres are attached to strings forming pendulums. The pendulums vary in mass and length, but the angles from the vertical are the same for all.

Rank these situations, from greatest to least, on the basis of the maximum speed of the bob at the bottom of the swing. In other words, put first the pendulum whose bob has the greatest speed going through the equilibrium point and put last the pendulum whose bob has the least speed at equilibrium.



Greatest 1________ 2________ 3________ 4________ 5________ 6_______ Least

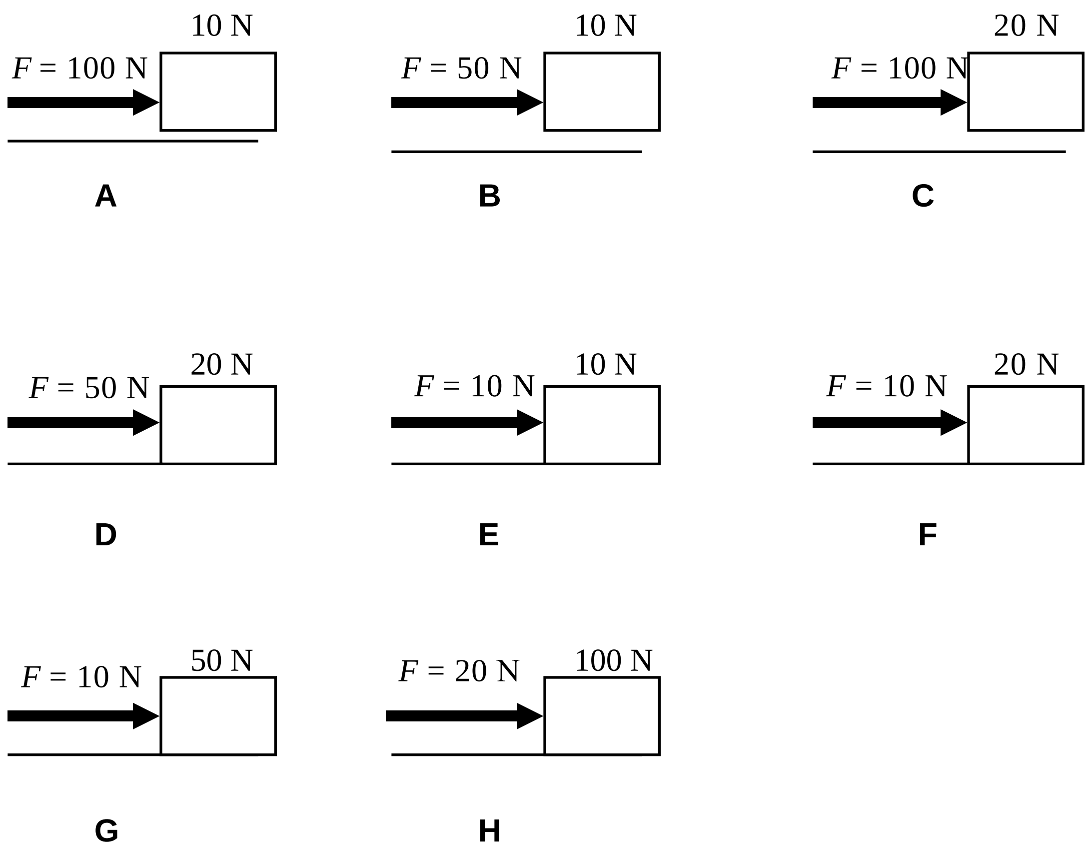
Or, the maximum speed is the same for all six of these. __________

Please carefully explain your reasoning.

Pushing Box with Friction—Change in Kinetic Energy [73]

Various similar boxes are being pushed for 10 m across a floor by a horizontal force as shown below. The weights of the boxes and the applied horizontal force for each case are given in the indicated figures. The frictional force is 20% of the weight of the box (g = 10 N/kg).

Rank the change in kinetic energy for each box from the greatest change in kinetic energy to the least change in kinetic energy. All boxes have an initial velocity of +10 m/s (+ direction is to the right and - to the left, with –4 < -2).



Greatest 1 _____ 2 _____ 3 _____ 4 _____ 5 _____ 6 _____ 7 _____ 8 _____ Least

Or, all changes in kinetic energy are the same._________

Please carefully explain your reasoning.