Inventory of Basic Conceptions in Mechanics

Thank you for taking this survey.

The survey is part of a battery of instruments designed by Prof. Ibrahim A. Halloun, in collaboration with educators in Lebanon and abroad. Each instrument is intended to identify factors that affect student understanding of particular aspects of science so that these factors be adequately accounted for in the design of instructional material.

For any information, please call Professor Halloun at: 01-680382, or send him an e-mail at: halloun@inco.com.lb.

*All data are **confidential.** Your identity will not be disclosed to any party.*

Please:

*Do **not write** anything on this questionnaire.*

*Mark your answers on the **answer sheet**, and follow marking instructions given there.*

*Answer **all questions** to the best of your knowledge. Do not skip any question.*

*Avoid guessing. Your answers should reflect what **you** actually and honestly think.*

*For efficient performance, read first the stem of an item and answer the question the way you know it **before** reading the provided alternatives marked (A) through (E). Once you answered the question your way, read the provided alternatives and choose the one that matches best your own answer.*

*Choose one, and **only one**, of the provided alternatives to answer any question.*

Plan to finish the survey in 30 minutes.

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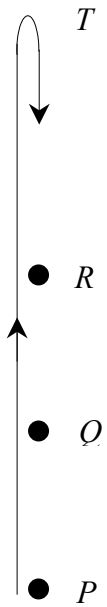
The accompanying figure shows a pebble thrown vertically upward from point *P*. The pebble goes through two points *Q* and *R* before reaching the highest point *T* of its trajectory. Point *Q* is halfway between points *P* and *R* (*PQ* = *QR*). Air resistance is negligible.



1. On its way up, how is the speed of the pebble at point *R* by comparison to its speed at point *Q*?
   (A) Half its speed at point *Q*.
   (B) Smaller than its speed at point *Q*, but not necessarily half as small.
   (C) Equal to its speed at point *Q*.
   (D) Twice its speed at point *Q*.
   (E) Greater than its speed at point *Q*, but not necessarily twice as big.

2. Which of the following forces act(s) on the pebble all along its upward motion?
   F_1: A force in the upward direction of motion
   F_2: A vertically downward attraction exerted by Earth
   (A) An almost constant F_2.
   (B) F_1 and F_2, each with an almost constant magnitude.
   (C) F_1 and F_2, each with a decreasing magnitude.
   (D) An almost constant F_1 and a decreasing F_2.
   (E) A decreasing F_1 and an almost constant F_2.

3. What happens to the speed and acceleration of the pebble as it reaches point *T* ?
   (A) Both its speed and its acceleration become zero for one instant.
   (B) Its speed becomes zero for one instant, and its acceleration remains constant.
   (C) Both its speed and its acceleration remain zero for a short time interval.
   (D) Its speed stays zero for a short time interval, and its acceleration becomes zero for only one instant.
   (E) Its speed stays zero for a short time interval, and its acceleration remains constant.

Just after it reaches the highest point *T* of its trajectory, the pebble falls back vertically downward.

4. By comparison to the speed it reached at point *Q* on the way up, the speed of the pebble at the same point *Q* on the way down is:
   (A) smaller than the speed it reached at this point on the way up.
   (B) equal to the speed it reached at this point on the way up.
   (C) twice the speed it reached at this point on the way up.
   (D) greater than the speed it reached at this point on the way up, but not necessarily twice as big.
   (E) of a degree that depends on how high point *T* is above point *R*.

* * *

Two metal balls are the same size but one is twice as heavy as the other. The balls are dropped at the same time, with no initial speed, from the roof of a tall building. Air resistance is negligible.

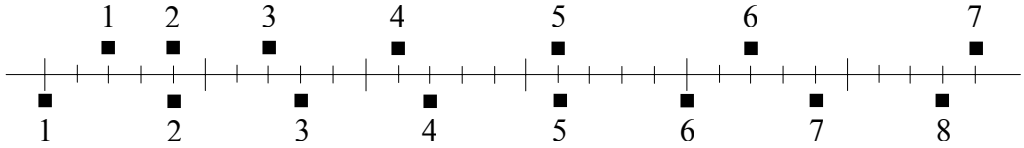
5. The time interval it takes the lighter ball to reach the ground below will be:
   (A) equal to the time interval it takes the heavier ball to get there.
   (B) twice the time interval it takes the heavier ball to get there.
   (C) greater than the time interval it takes the heavier ball to get there, but not necessarily twice as long.
   (D) greater than, or equal to, the time interval it takes the heavier ball to get there, depending on how tall the building is.
   (E) smaller than the time interval it takes the heavier ball to get there.

6. How are the speeds of the two balls throughout their fall?

(A) the speed of each ball increases for a while and remains constant afterwards; the heavier ball touches the ground with the greater speed.
(B) the speed of each ball increases for a while and remains constant afterwards; the two balls touch the ground with the same speed.
(C) the speed of each ball continuously increases; the heavier ball touches the ground with the greater speed.
(D) the speed of each ball continuously increases; the two balls touch the ground with the same speed.
(E) the speed of each ball may increase for a while, and then remain constant or decrease depending on how tall the building is.

* * *

The positions of two blocks at successive 0.20-second time intervals are represented by the numbered squares in the figure below. The blocks are moving toward the right.

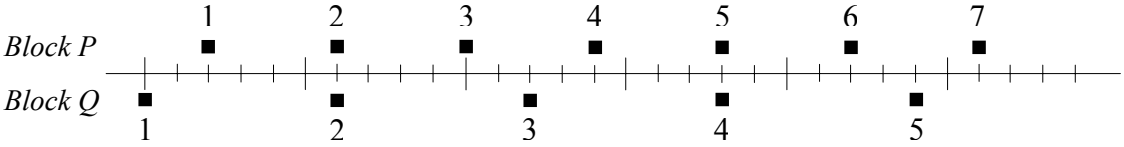


7. Do the blocks ever have the same speed?

(A) No.
(B) Yes, at instant 2.
(C) Yes, at instant 5.
(D) Yes, at instants 2 and 5.
(E) Yes, at some time between instants 3 and 4.

* * *

The positions of two blocks *P* and *Q* at successive 0.20-second time intervals are represented by the numbered squares in the figure below. The blocks are moving toward the right.

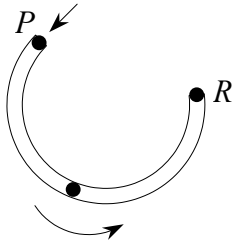


8. The accelerations of the two blocks are related as follows:

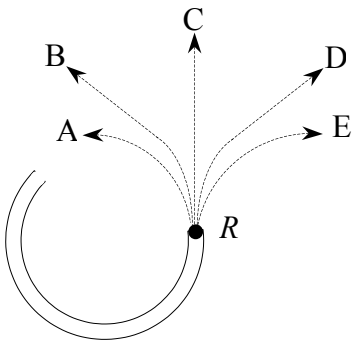
(A) The acceleration of *P* equals the acceleration of *Q*. Both accelerations are zero.
(B) The acceleration of *P* equals the acceleration of *Q*. Both accelerations are greater than zero.
(C) The acceleration of *P* is smaller than the acceleration of *Q*.
(D) The acceleration of *P* is greater than the acceleration of *Q*.
(E) There are times at which the two accelerations are equal and times at which they are not.

* * *

The accompanying figure shows an open circular channel anchored to a frictionless horizontal tabletop. You are looking down at the table. A marble is shot at high speed into the channel at *P* and exits at *R* without rolling on the tabletop.



9. Which path in the adjacent figure would the marble most closely follow across the frictionless tabletop after it exits the channel at *R*?



10. Ignoring air resistance, the speed of the marble along the chosen path outside the channel:
    (A) remains constant all along.
    (B) continuously increases.
    (C) increases for a while and remains constant thereafter.
    (D) remains constant for a while and decreases thereafter.
    (E) continuously decreases.

11. Which of the following forces act(s) on the marble when it moves along the chosen path outside the channel?

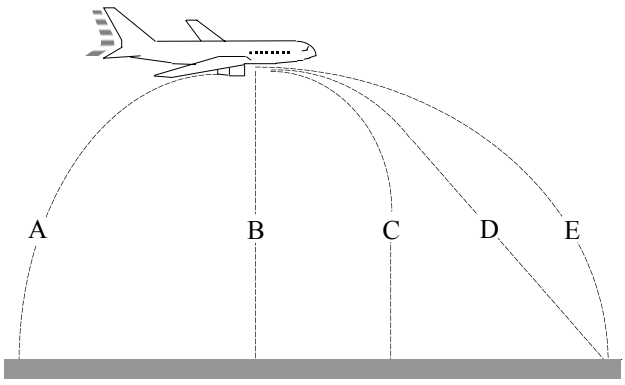
    F_1: A horizontal force in the direction of motion
    F_2: A vertically downward attraction exerted by Earth
    F_3: A vertically upward force exerted by the table

    (A) F_1.
    (B) F_2.
    (C) F_1 and F_2.
    (D) F_2 and F_3.
    (E) F_1, F_2 and F_3.

* * *

A bowling ball accidentally falls out of the cargo bay of an airliner as it flies along in a horizontal direction.

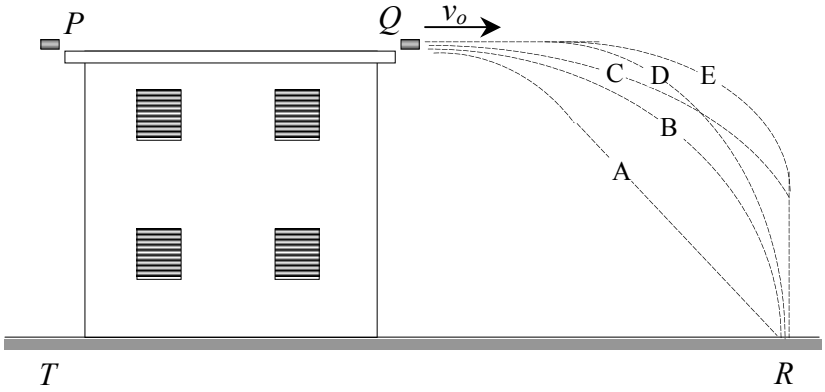
12. As observed by a person standing on the ground and viewing the plane as in the figure at right, which path would the bowling ball most closely follow after leaving the airplane?



* * *

A hockey puck (thick metallic disc) is kicked with high speed v_o, horizontally off edge *Q* of the roof of a two-story building.

13. Which of paths (A) through (E) shown in the figure below would the puck most closely follow as it flies from point *Q* to point *R* where it hits the ground?



14. Which of the following forces act(s) on the puck during its flight from *Q* to *R*?

F_1: A downward push exerted by air
F_2: An upward push exerted by air
F_3: A vertically downward attraction exerted by Earth
F_4: A force in the variable direction of motion

(A) F_1 and F_3.
(B) F_1 and F_4.
(C) F_2 and F_3.
(D) F_1, F_3 and F_4.
(E) F_2, F_3 and F_4.

15. During its fall, the speed of the ball:

(A) remains constant all the way down.
(B) remains constant for a while and increases thereafter.
(C) continuously increases all the way down.
(D) increases for a while and remains constant thereafter.
(E) increases for a while and decreases thereafter.

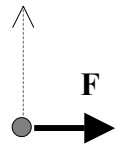
At the same time the puck above is kicked off edge *Q* with speed v_o, another identical puck is dropped from edge *P* of the same roof with no initial speed. As shown in the figure above, the latter puck hits the floor below at point *T*.

16. Assuming that air resistance is negligible, the time interval it takes the latter puck to fall from *P* to *T* is:

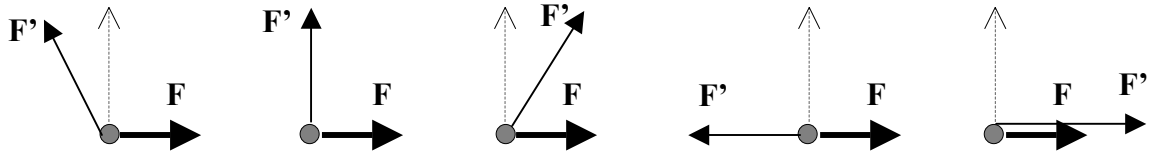
(A) smaller than the time interval it takes the former puck to fly from *Q* to *R*
(B) equal to the time interval it takes the former puck to fly from *Q* to *R*.
(C) smaller or equal to the time interval it takes the former puck to fly from *Q* to *R*, depending on how tall the building is.
(D) greater than the time interval it takes the former puck to fly from *Q* to *R*.
(E) greater or equal to the time interval it takes the former puck to fly from *Q* to *R*, depending on how tall the building is.

* * *

The figure at right shows a smooth hockey puck on a frictionless, horizontal floor. You are looking down at the puck. The puck slides along a straight line in the direction of the dotted arrow. Two constant forces **F** and **F'** are exerted on the puck. Force **F** is exerted as shown by the heavy print arrow pointing to the right.



17. Which of the arrows below best represents the other force **F'**?



(A) (B) (C) (D) (E)

18. When the two forces **F** and **F'** act together on the puck throughout its motion, its speed:

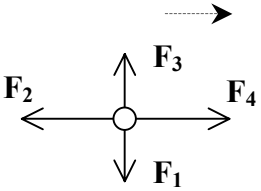
(A) continuously decreases.
(B) remains constant.
(C) remains constant for a while and decreases thereafter.
(D) continuously increases.
(E) increases for a while and remains constant thereafter.

19. If the two forces **F** and **F'** could not be exerted together on the puck throughout its motion, what could be done to maintain the motion of the puck along the same straight line and with the same kind of speed described by your answer to the previous question?

(A) Kick the puck in the direction of the dotted arrow, and let it slide thereafter on its own, without exerting any force on it.
(B) Alternate between the two original forces **F** and **F'**. First exert **F** alone on the puck for some time interval, and then **F'** instead of **F** for an equal time interval. Keep switching like this from one force to another throughout the puck's motion.
(C) Exert a single force in the direction of motion with magnitude proportional to the speed at any given time.
(D) Exert continuously a single constant force in the direction of motion with magnitude equal to the sum of the magnitudes of **F** and **F'**.
(E) Exert continuously a single constant force in the direction of motion with magnitude smaller than the sum of the magnitudes of **F** and **F'**.

* * *

Four forces, $\mathbf{F_1}$, $\mathbf{F_2}$, $\mathbf{F_3}$ and $\mathbf{F_4}$ are exerted together on a hockey puck. The puck moves at constant speed along a straight line in the direction of $\mathbf{F_4}$. The arrows in the accompanying figure represent the directions of the four forces but not their magnitudes.



20. Among the following relationships, which one represents best how the magnitudes of the four forces are related?

(A) $F_4 = F_2$ and $F_3 = F_1$.
(B) $F_4 = F_2$ and $F_3 > F_1$.
(C) $F_4 > F_2$ and $F_3 > F_1$.
(D) $F_4 > F_2$ and $F_3 = F_1$.
(E) $F_4 > F_2$ and $F_3 < F_1$.

* * *

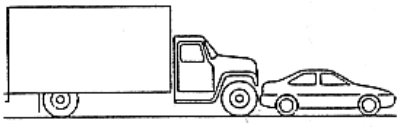
21. A car is driven on a horizontal road. Which of the following forces push the car in the direction of motion?

$\mathbf{F_1}$: Forces exerted by the engine of the car on its tires
$\mathbf{F_2}$: Forces exerted by the tires of the car on the road
$\mathbf{F_3}$: Forces exerted by the road on the tires of the car

(A) F_1.
(B) F_2.
(C) F_3.
(D) F_1 and F_2.
(E) None of the above forces.

* * *

A compact car breaks down out on a horizontal road. A large truck gives it a push back into town as shown in the figure at right.



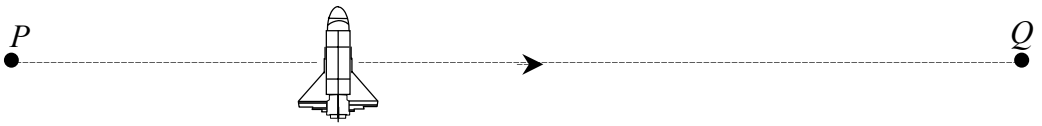
22. As the truck touches the car and begins to push it:
    (A) the two vehicles do not exert any force on one another.
    (B) the truck exerts a force on the car, but the car does not exert any force on the truck.
    (C) the truck first exerts a force on the car, then a short while afterwards the car starts exerting a force on the truck.
    (D) the car first exerts a force on the truck, then a short while afterwards the truck starts exerting a force on the car.
    (E) the two vehicles exert forces on one another at the same time.

23. As the truck begins to move the car on the horizontal road:
    (A) the two vehicles do not exert any force on one another.
    (B) the truck exerts a force on the car, but the car does not exert any force on the truck.
    (C) the two vehicles exert forces of the same magnitude on one another.
    (D) each vehicle exerts a force on the other, but the truck exerts the bigger force.
    (E) each vehicle exerts a force on the other, but the car exerts the bigger force.

24. After a while, the truck reaches a cruising speed that it maintains constant afterwards. While the truck pushes the car with this constant speed:
    (A) the two vehicles do not exert any force on one another.
    (B) the truck exerts a force on the car, but the car does not exert any force on the truck.
    (C) the two vehicles exert forces of the same magnitude on one another.
    (D) each vehicle exerts a force on the other, but the truck exerts the bigger force.
    (E) each vehicle exerts a force on the other, but the car exerts the bigger force.

* * *

A spaceship is flying in outer space with its engine turned off. At a certain point *P* in space, the spaceship starts drifting sideways with a constant speed and in a straight line until it reaches a distant point *Q* in space.

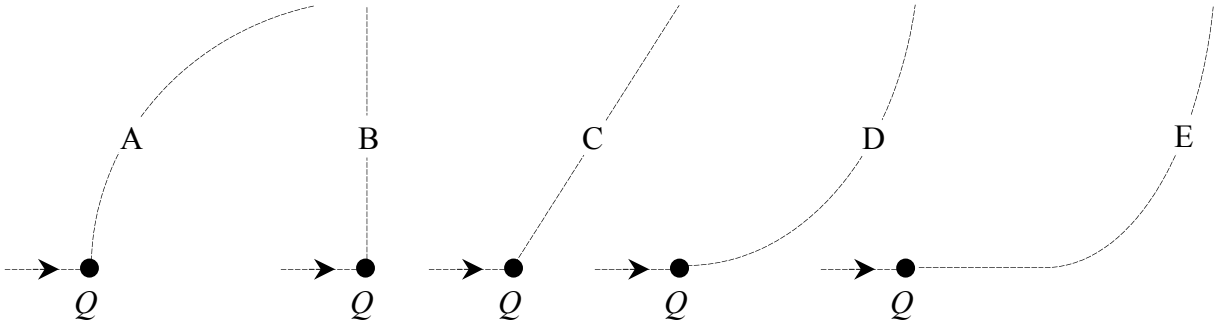


25. Which of the forces below may have caused the spaceship to move the way it did between points *P* and *Q*?
    F_1: A force in the direction of motion exerted by some planets or other celestial objects
    F_2: A force in the direction of motion due to the original thrust of the spaceship
    F_3: An internal impulse developed gradually by the spaceship as it moves from *P* to *Q*

    (A) F_1.
    (B) F_2.
    (C) F_3.
    (D) F_1 and F_2.
    (E) None. The spaceship can move the way it did between *P* and *Q* without being driven by any internal or external force.

When it gets to point *Q*, the spaceship's engine is turned on so as to produce, from that moment on, a constant thrust (force on the spaceship) at right angles to the line *PQ*.

26. Which of the trajectories below best represents the path of the spaceship beyond point *Q*?



27. The speed of the spaceship beyond point *Q*, and along the path you have chosen above, is:
    (A) continuously decreasing.
    (B) constant.
    (C) constant for a while and decreasing thereafter.
    (D) continuously increasing.
    (E) increasing for a while and constant thereafter.

* * *

The figure below shows two hockey pucks *P* and *Q* sitting on a frictionless horizontal table. You are looking down at the table. The two pucks are the same size, but puck *P* is twice as heavy as puck *Q*.

The two pucks are now being pushed on the table in the same direction and with equal forces, **F**, until they reach the finish line.

28. The time interval it takes the heavier puck *P* to reach the finish line will be:
    (A) twice the time interval it takes the lighter puck *Q* to get there.
    (B) greater than the time interval it takes the lighter puck *Q* to get there, but not necessarily twice as long.
    (C) equal to the time interval it takes the lighter puck *Q* to get there.
    (D) half the time interval it takes the lighter puck *Q* to get there.
    (E) smaller than the time interval it takes the lighter puck *Q* to get there, but not necessarily half as long.

29. At the finish line, the speed of the heavier puck *P* will be:
    (A) twice the speed of the lighter puck *Q* at this line.
    (B) greater than the speed of the lighter puck *Q* at this line, but not necessarily twice as big.
    (C) equal to the speed of the lighter puck *Q* at this line.
    (D) half the speed of the lighter puck *Q* at this line.
    (E) smaller than the speed of the lighter puck *Q* at this line, but not necessarily half as small.

30. Throughout their motion, the acceleration of the heavier puck *P* is:
    (A) twice the acceleration of the lighter puck *Q*.
    (B) greater than the acceleration of the lighter puck *Q*, but not necessarily twice as big.
    (C) equal to the acceleration of the lighter puck *Q*.
    (D) half the acceleration of the lighter puck *Q*.
    (E) smaller than the acceleration of the lighter puck *Q*, but not necessarily half as small.

* * *

31. You are pushing a box with a constant horizontal force **F**. The box is then moving across a horizontal floor with a constant speed v_o.

    Consider the following two forces:

    $\mathbf{F_1}$: The weight of the box
    $\mathbf{F_2}$: A net horizontal force that resists the motion of the box

    The magnitude of the force **F** you exert on the box is:
    (A) equal to the magnitude of $\mathbf{F_1}$.
    (B) greater than the magnitude of $\mathbf{F_1}$.
    (C) equal to the magnitude of $\mathbf{F_2}$.
    (D) greater than the magnitude of $\mathbf{F_2}$.
    (E) greater than the magnitude of either $\mathbf{F_1}$ or $\mathbf{F_2}$.

32. You now push the box on the same horizontal floor with a constant horizontal force that is twice as big as the force **F** exerted in the previous question. The box then moves:
    (A) with a constant speed that is twice the speed v_o in the previous question.
    (B) with a constant speed that is greater than the speed v_o in the previous question, but not necessarily twice as big.
    (C) for a while with a constant speed that is greater than the speed v_o in the previous question, and with a continuously increasing speed thereafter.
    (D) with a continuously increasing speed.
    (E) for a while with an increasing speed, and with a constant speed thereafter.

33. After pushing it for a while, you loose contact with the box and you stop exerting any force on it. The box will then:
    (A) immediately come to a stop.
    (B) immediately start slowing to a stop.
    (C) continue moving with a constant speed.
    (D) continue moving with a constant speed for a while and then slow to a stop.
    (E) continue moving with an increasing speed for a while and then start slowing to a stop.

* * *