Force Concept Inventory

1. Two metal balls are the same size, but one weighs twice as much as the other. The balls are dropped from the top of a two story building at the same instant of time. The time it takes the balls to reach the ground below will be:

   (A) about half as long for the heavier ball.
   (B) about half as long for the lighter ball.
   (C) about the same time for both balls.
   (D) considerably less for the heavier ball, but not necessarily half as long.
   (E) considerably less for the lighter ball, but not necessarily half as long.

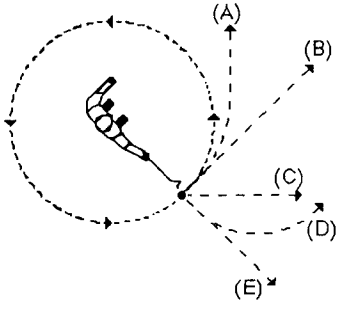
2. Imagine a head-on collision between a large truck and a small compact car. During the collision,

   (A) the truck exerts a greater amount of force on the car than the car exerts on the truck.
   (B) the car exerts a greater amount of force on the truck than the truck exerts on the car.
   (C) neither exerts a force on the other, the car gets smashed simply because it gets in the way of the truck.
   (D) the truck exerts a force on the car but the car doesn't exert a force on the truck.
   (E) the truck exerts the same amount of force on the car as the car exerts on the truck.

3. Two steel balls, one of which weighs twice as much as the other, roll off of a horizontal table with the same speeds. In this situation:

   (A) both balls impact the floor at approximately the same horizontal distance from the base of the table.
   (B) the heavier ball impacts the floor at about half the horizontal distance from the base of the table than does the lighter.
   (C) the lighter ball impacts the floor at about half the horizontal distance from the base of the table than does the heavier.
   (D) the heavier ball hits considerably closer to the base of the table than the lighter, but not necessarily half the horizontal distance.
   (E) the lighter ball hits considerably closer to the base of the table than the heavier, but not necessarily half the horizontal distance.

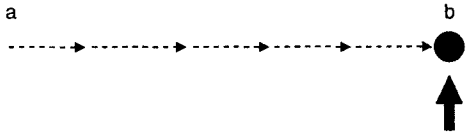
4. A heavy ball is attached to a string and swung in a circular path in a horizontal plane as illustrated in the diagram to the right. At the point indicated in the diagram, the string suddenly breaks at the ball. If these events were observed from directly above, indicate the path of the ball after the string breaks.



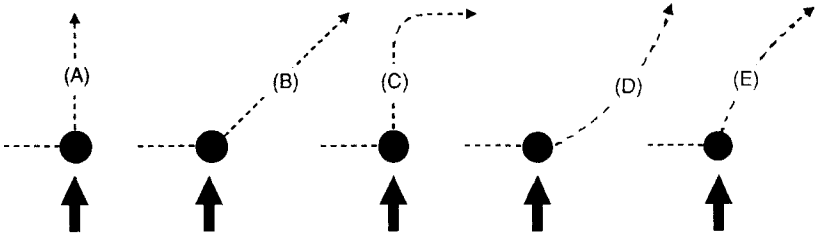
5. A boy throws a steel ball straight up. **Disregarding any effects of air resistance**, the force(s) acting on the ball until it returns to the ground is (are):

   (A) its weight vertically downward along with a steadily decreasing upward force.
   (B) a steadily decreasing upward force from the moment it leaves the hand until it reaches its highest point beyond which there is a steadily increasing downward force of gravity as the object gets closer to the earth.
   (C) a constant downward force of gravity along with an upward force that steadily decreases until the ball reaches its highest point, after which there is only the constant downward force of gravity.
   (D) a constant downward force of gravity only.
   (E) none of the above, the ball falls back down to the earth simply because that is its natural action.

* **Use the statement and diagram below to answer the next four questions:**
* **The diagram depicts a hockey puck sliding, with a constant velocity, from point "a"to point "b" along a frictionless horizontal surface. When the puck reaches point "b", it receives an instantaneous horizontal "kick" in the direction of the heavy print arrow.**



6. Along which of the paths below will the hockey puck move after receiving the "kick" ?



7. The speed of the puck just **after** it receives the "kick"?

   (A) Equal to the speed "v_o" it had before it received the "kick".
   (B) Equal to the speed "v" it acquires from the "kick", and independent of the speed "v_o".
   (C) Equal to the arithmetic sum of speeds "v_o" and "v".
   (D) Smaller than either of speeds "v_o" or "v".
   (E) Greater than either of speeds "v_o" or "v", but smaller than the arithmetic sum of these two speeds.

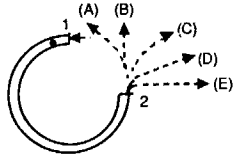
8. Along the **frictionless** path you have chosen, how does the speed of the puck vary **after** receiving the "kick"?

   (A) No change.
   (B) Continuously increasing.
   (C) Continuously decreasing.
   (D) Increasing for a while, and decreasing thereafter.
   (E) Constant for a while, and decreasing thereafter.

9. The main forces acting, **after** the "kick", on the puck along the path you have chosen are:

   (A) the downward force due to gravity and the effect of air pressure.
   (B) the downward force of gravity and the horizontal force of momentum **in the direction of motion.**
   (C) the downward force of gravity, the upward force exerted by the table, and a horizontal force acting on the puck **in the direction of motion.**
   (D) the downward force of gravity and an upward force exerted on the puck by the table.
   (E) gravity does not exert a force on the puck, it falls because of the intrinsic tendency of the object to fall to its natural place.

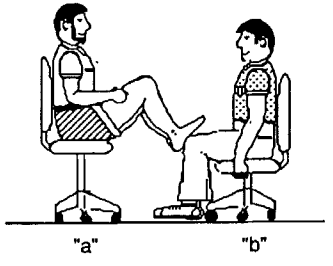
10. The accompanying diagram depicts a semicircular channel that has been securely attached, in a **horizontal plane**, to a table top. A ball enters the channel at "1" and exits at "2". Which of the path representations would most nearly correspond to the path of the ball as it exits the channel at "2" and rolls across the table top.



* **Two students, student "a" who has a mass of 95 kg and student "b" who has a mass of 77 kg sit in identical office chairs facing each other. Student "a" places his bare feet on student "b's" knees, as shown below. Student "a" then suddenly pushes outward with has feet, causing both chairs to move.**

11. In this situation,

   (A) neither student exerts a force on the other.
   (B) student "a" exerts a force on "b", but "b" doesn't exert any force on "a".
   (C) each student exerts a force on the other but "b" exerts the larger force.
   (D) each student exerts a force on the other but "a" exerts the larger force.
   (E) each student exerts the same amount of force on the other.



12. A book is at rest on a table top. Which of the following force(s) is(are) acting on the book?

   1. A downward force due to gravity.
   2. The upward force by the table.
   3. A net downward force due to air pressure.
   4. A net upward force due to air pressure.

   (A) 1 only
   (B) 1 and 2
   (C) 1, 2, and 3
   (D) 1, 2, and 4
   (E) none of these, since the book is at rest there are no forces acting on it.

* **Refer to the following statement and diagram while answering the next two questions.**

A large truck breaks down out on the road and receives a push back into town by a small compact car.

13. While the car, still pushing the truck, is **speeding up** to get up to cruising speed;

   (A) the amount of force of the car pushing against the truck is equal to that of the truck pushing back against the car.
   (B) the amount of force of the car pushing against the truck is less than that of the truck pushing back against the car.
   (C) the amount of force of the car pushing against the truck is greater than that of the truck pushing against the car.
   (D) the car's engine is running so it applies a force as it pushes against the truck but the trucks engine is not running so it can't push back against the car, the truck is pushed forward simply because it is in the way of the car.
   (E) neither the car nor the truck exert any force on the other, the truck is pushed forward simply because it is in the way of the car.

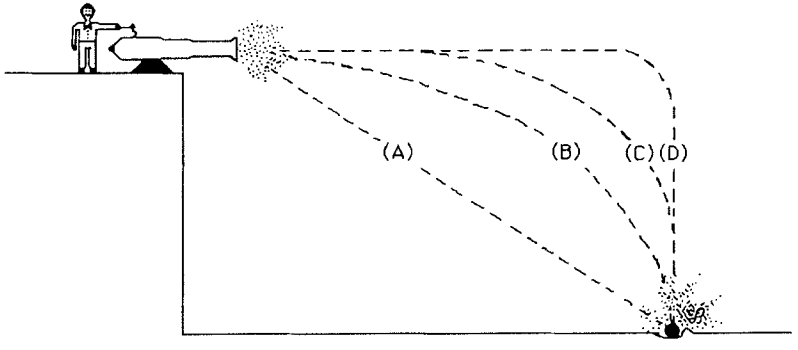
14. After the person in the car, while pushing the truck, reaches the cruising speed at which he/she wishes to continue to travel at a constant speed;

   (A) the amount of force of the car pushing against the truck is equal to that of the truck pushing back against the car.
   (B) the amount of force of the car pushing against the truck is less than that of the truck pushing back against the car.
   (C) the amount of force of the car pushing against the truck is greater than that of the truck pushing against the car.
   (D) the car's engine is running so it applies a force as it pushes against the truck but the trucks engine is not running so it can't push back against the car, the truck is pushed forward simply because it is in the way of the car.
   (E) neither the car nor the truck exert any force on the other, the truck is pushed forward simply because it is in the way of the car.

15. When a rubber ball dropped from rest bounces off the floor, its direction of motion is reversed because;

(A) energy of the ball is conserved.
(B) momentum of the ball is conserved.
(C) the floor exerts a force on the ball that stops its fall and then drives it upward.
(D) the floor is in the way and the ball has to keep moving.
(E) none of the above.

16. Which of the paths in the diagram to the right best represents the path of the cannon ball?



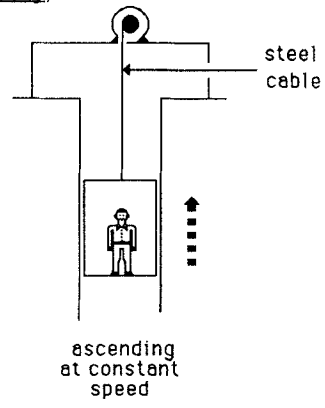
17. A stone falling from the roof of a single story building to the surface of the earth;

(A) reaches its maximum speed quite soon after release and then falls at a constant speed thereafter.
(B) speeds up as it falls, primarily because the closer the stone gets to the earth, the stronger the gravitational attraction.
(C) speeds up because of the constant gravitational force acting on it.
(D) falls because of the intrinsic tendency of all objects to fall toward the earth.
(E) falls because of a combination of the force of gravity and the air pressure pushing it downward.

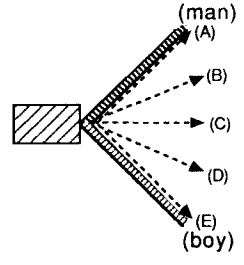
* **When responding to the following question, assume that any <u>frictional forces</u> due to air resistance are so small that they <u>can be</u> <u>ignored</u>.**

18. An elevator, as illustrated, is being lifted up an elevator shaft by a steel cable. When the elevator is moving up the shaft at a **<u>constant velocity</u>**;

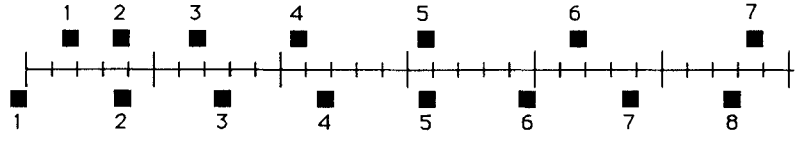
(A) the upward force on the elevator by the cable is greater than the downward force of gravity.
(B) the amount of upward force on the elevator by the cables equal to that of the downward force of gravity
(C) the upward force on the elevator by the cable is less than the down ward force of gravity.
(D) it goes up because the cable is being shortened, not because of the force being exerted on the elevator by the cable.
(E) the upward force on the elevator by the cable is greater than the downward force due to the combined effects of air pressure and the force of gravity.



19. Two people, a large man and a boy, are pulling as hard as they can on two ropes attached to a crate as illustrated in the diagram to the right. Which of the indicated paths (A-E) would most likely correspond to the path of the crate as they pull it along?



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

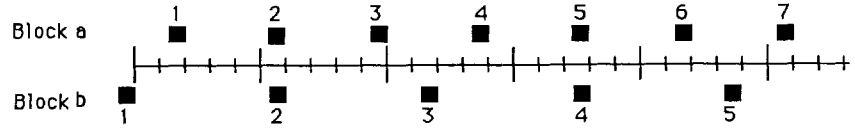


(continued on the next page)

20. Do the blocks ever have the same speed?

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

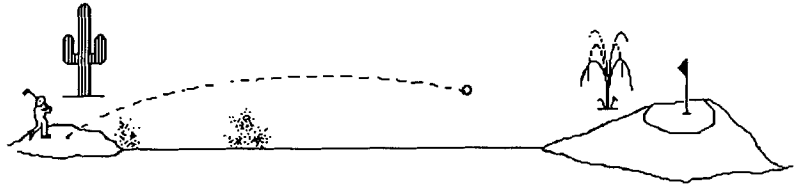
* **The positions of two blocks at successive equal time intervals are represented by numbered squares in the diagram below. The blocks are moving toward the right.**



21. The acceleration of the blocks are related as follows:

(A) acceleration of "a" > acceleration of "b"
(B) acceleration of "a" = acceleration "b" > 0
(C) acceleration of ""b" > acceleration "a"
(D) acceleration of "a" = acceleration of "b" = 0
(E) not enough information to answer.

22. A golf ball driven down a fairway is observed to travel through the air with a trajectory (flight path) similar to that in the depiction below.

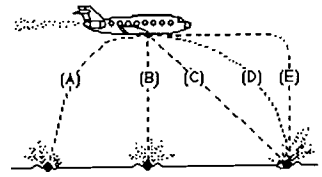


Which following force(s) is(are) acting on the golf ball during its entire flight?

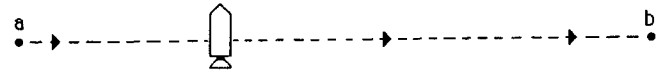
1. the force of gravity
2. the force of the "hit"
3. the force of air resistance

(A) 1 only
(B) 1 and 2
(C) 1, 2, and 3
(D) 1 and 3
(E) 2 and 3

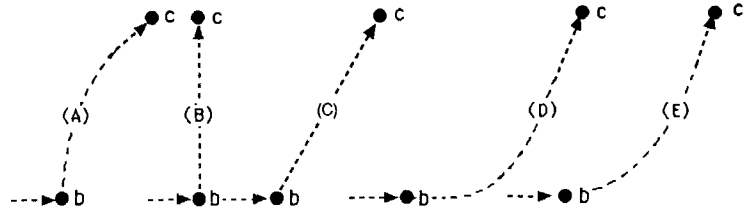
23. A bowling ball accidently falls out of the cargo bay of an airliner as it flies along in a horizontal direction. As seen from the ground, which path would the bowling ball most closely follow after leaving the airplane?



* **When answering the next four questions, refer to the following statement and diagram.**
* **A rocket, drifting sideways in outer space from position "a" to position "b". is subject to no outside forces. At "b", the rocket's engine starts to produce a constant thrust at right angles to line "ab". The engine turns off again as the rocket reaches some point "c".**



24. Which path below best represents the path of the rocket between "b" and "c"?



25, As the rocket moves from "b" to "c", its **speed** is

(A) constant.
(B) continuously increasing.
(C) continuously decreasing.
(D) increasing for a while and constant thereafter.
(E) constant for a while and decreasing thereafter.

Physics Trick of the Month

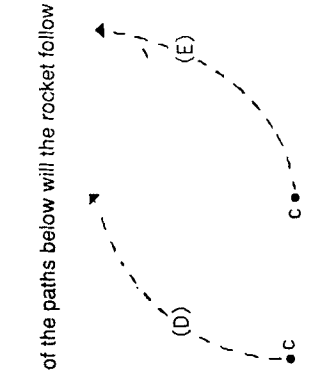
The Biased Penny

I'll bet you didn't know that if you spin a shiny new U.S. penny on a glass table top (the surface *must* be glass), when it stops spinning it will fall tails about eight out of ten times. The probability varies slightly with each penny. I assume this is because when the Mint stamps pennies out of zinc sheets, before coating them with copper, an imperceptible bias occurs on the rims.

You can borrow anyone's penny, provided it isn't old and worn, find a glass surface, and consistently win by betting on each spin that the penny will fall tails.

Martin Gardner, *Hendersonville, NC 28739*

26. At "c" the rocket's engine is turned off. Which of the paths below will the rocket follow beyond "c"?



27. Beyond "c", the speed of the rocket is;

(A) constant.
(B) continuously increasing.
(C) continuously decreasing.
(D) increasing for a while and constant thereafter.
(E) constant for a while and decreasing thereafter.

28. A large box is being pushed across the floor at a **constant speed** of 4.0 m/s. What can you conclude about the forces acting on the box

(A) If the force applied to the box is doubled, the constant speed of the box will increase to 8.0 m/s.
(B) The amount of force applied to move the box at a constant speed must be more than its weight.
(C) The amount of force applied to move the box at a constant speed must be equal to the amount of the frictional forces that resist its motion.
(D) The amount of force applied to move the box at a constant speed must be more than the amount of the frictional forces that resist its motion.
(E) There is a force being applied to the box to make it move but the external forces such as friction are not "real" forces they just resist motion.

29. If the force being applied to the box in the preceding problem is suddenly discontinued, the box will;

(A) stop immediately.
(B) continue at a constant speed for a very short period of time and then slow to a stop.
(C) immediately start slowing to a stop.
(D) continue at a constant velocity.
(E) increase its speed for a very short period of time, then start slowing to a stop.

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