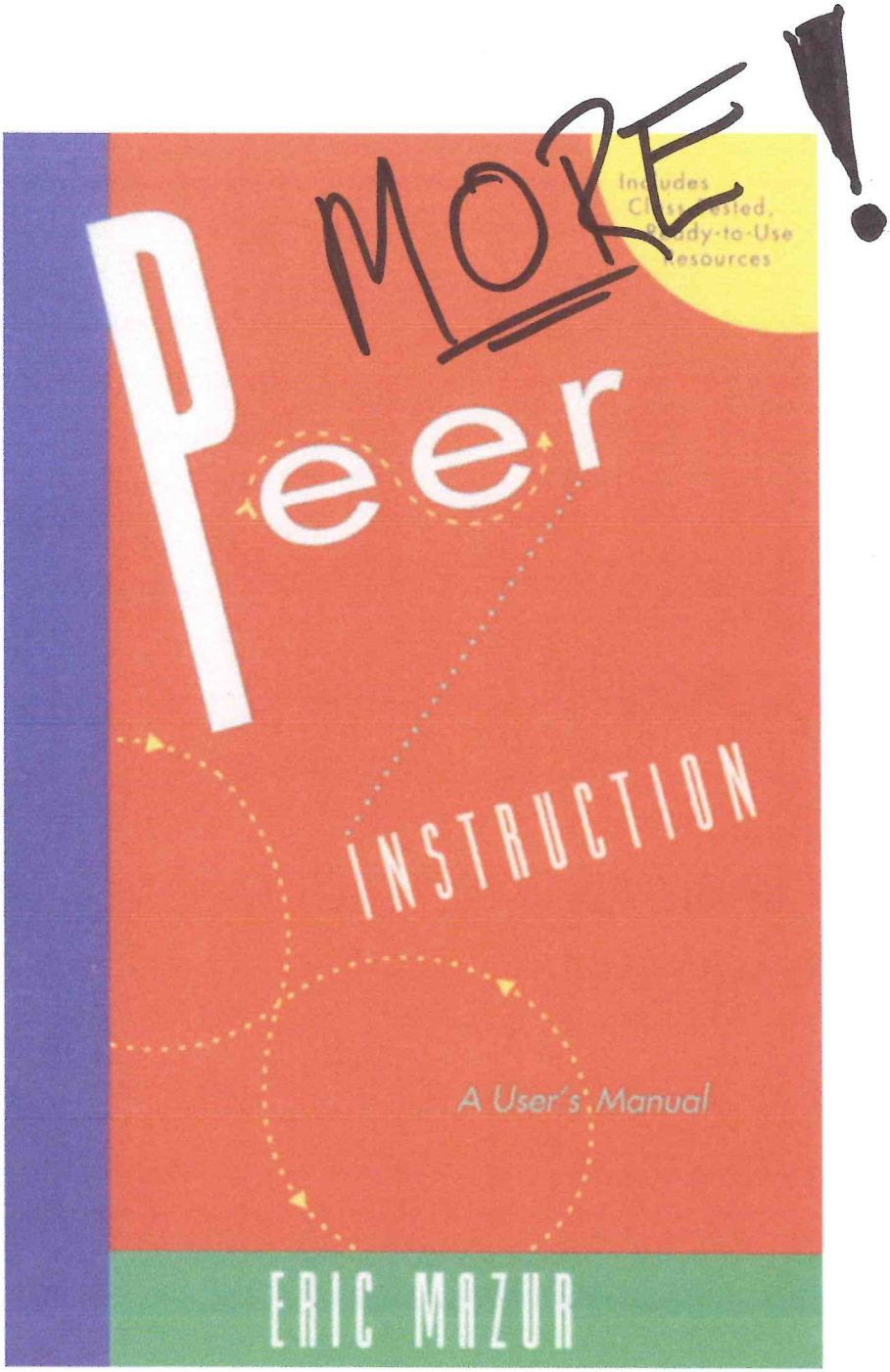
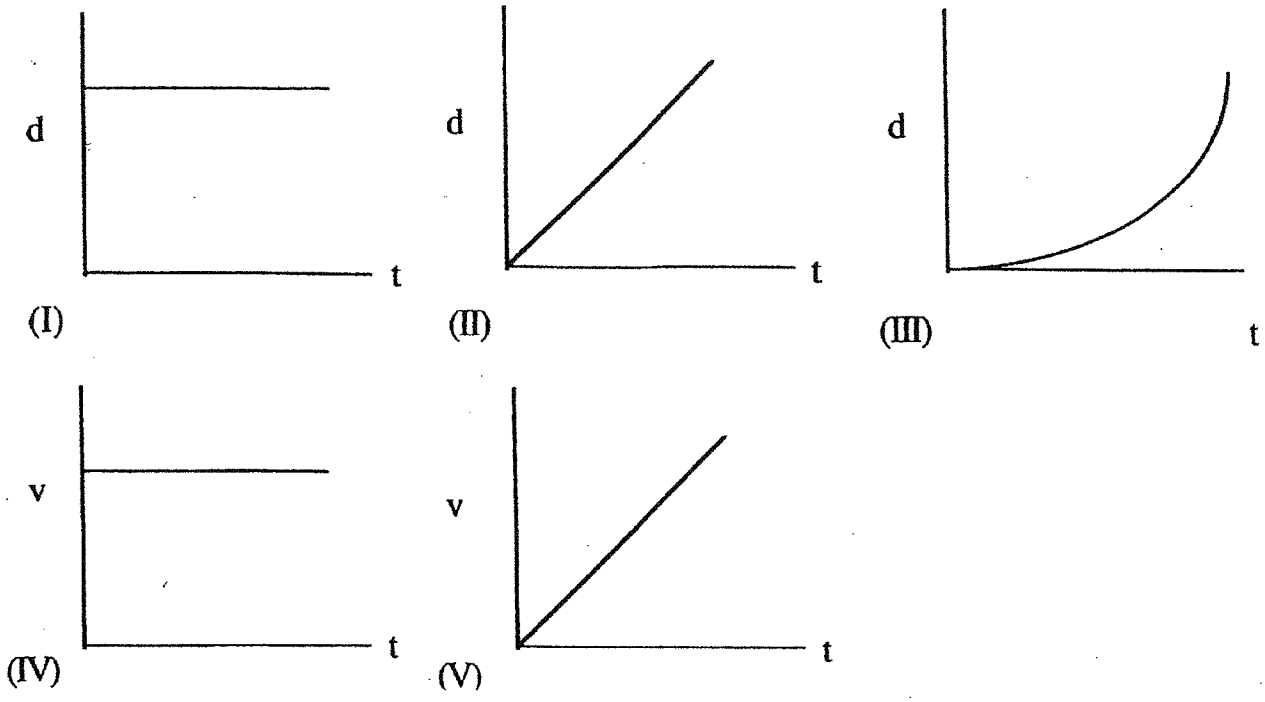

MORE!
Peer
INSTRUCTION
A User's Manual
ERIC MAZUR

Take a piece of 8.5" × 11" piece of paper and fold it once. Then fold it again. Repeat this folding 50 times. How tall will the paper be after 50 folds?


1) About 1 cm
2) About 2 cm
3) About 5 cm
4) About 1 kilometre
5) About 150 million kilometres

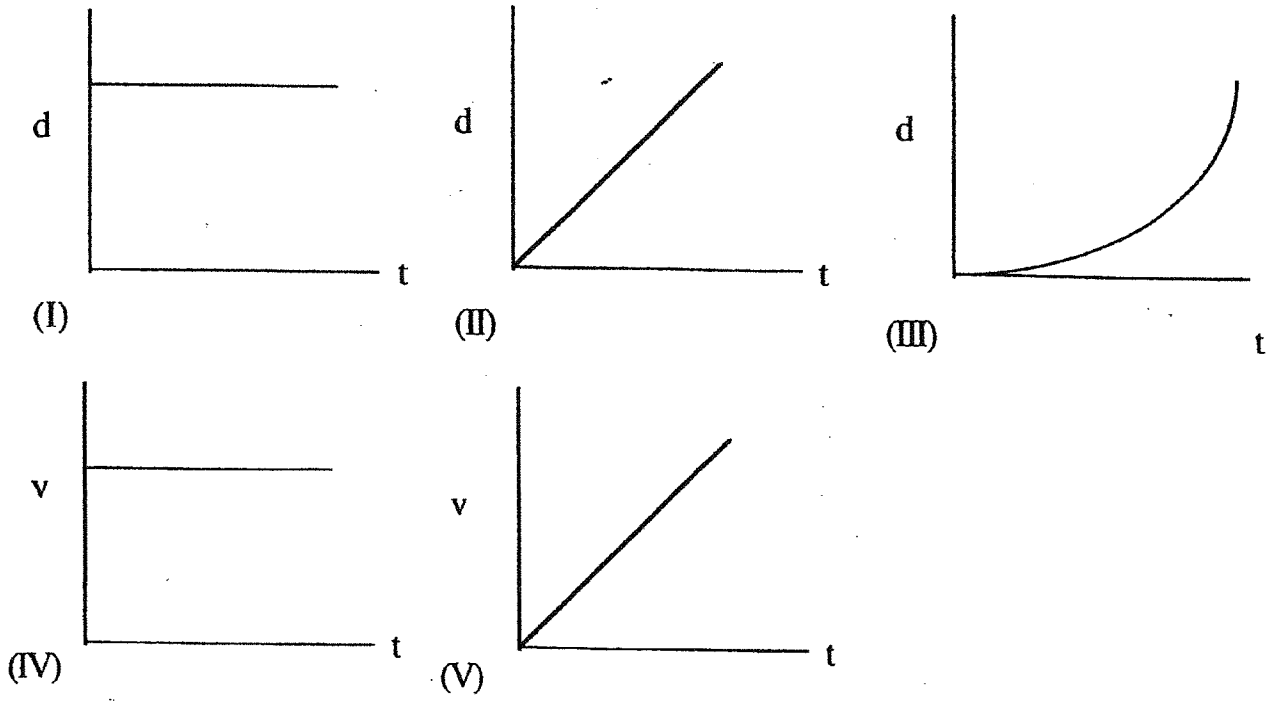
Look at the following graphs below:




Which of the above graphs represent(s) an object at rest?

1. I only
2. I and IV
3. III only
4. II and IV
5. V only

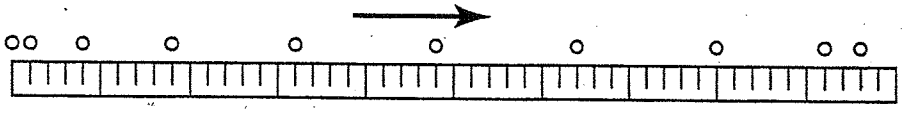
Look at the following graphs below:



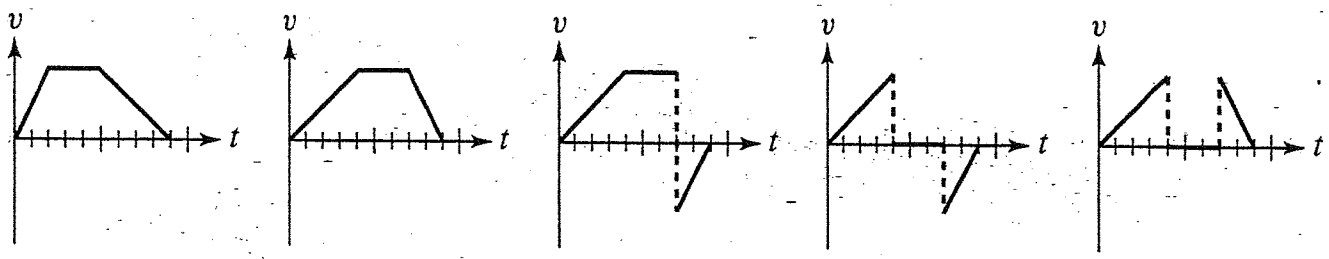

Which of the above graphs represent(s) an object moving with a constant speed?

1. I only
2. I and III
3. III only
4. II and IV
5. V only

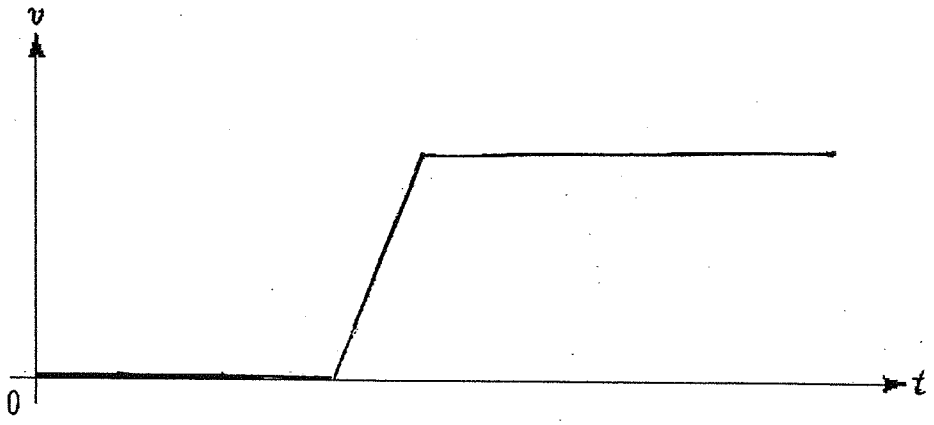
This diagram represents a multiflash photograph of an object moving along a horizontal surface. The positions indicated in the diagram are separated by equal time intervals. The first flash occurred just as the object started to move and the last just as it came to rest.



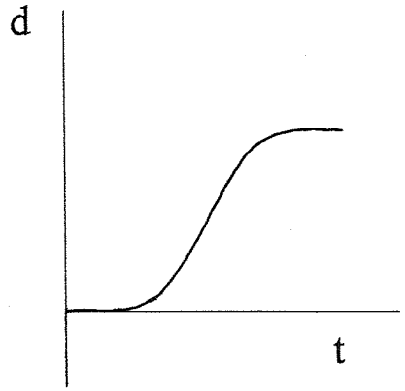
Which of the graphs 1–5 below best represents the object's velocity as a function of time?

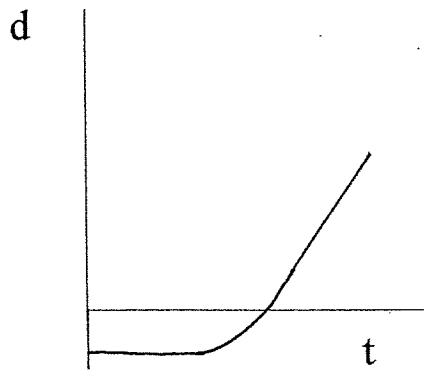


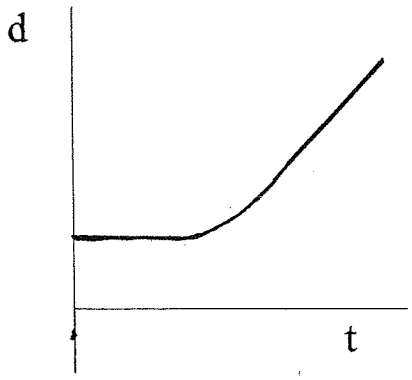
Below is the *v-t* graph of the motion of a motorcycle.

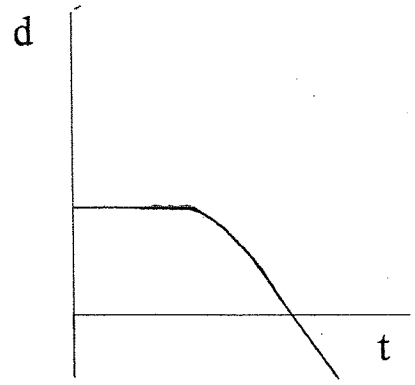



Which of the following *d-t* graphs best represents this motion?

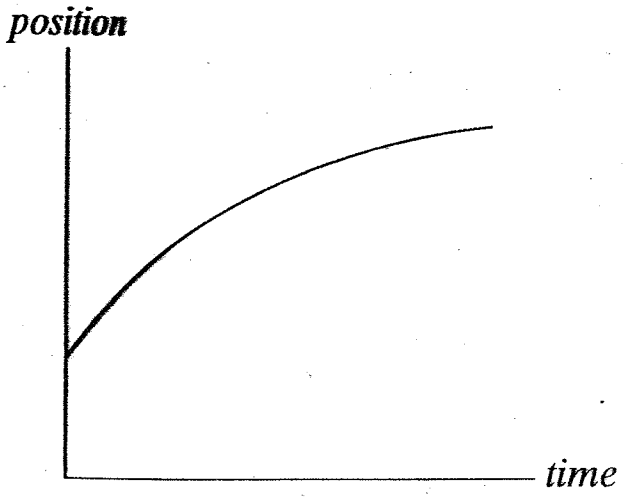


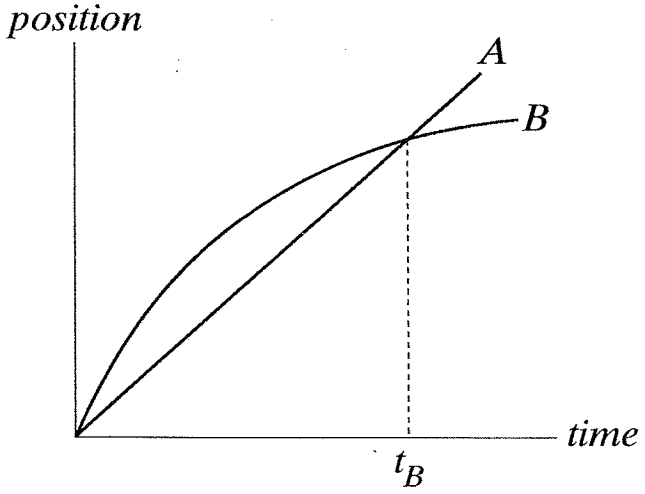



A train car moves along a long straight track. The graph shows the position as a function of time for this train. The graph shows that the train:




1. speeds up all the time.
2. slows down all the time.
3. speeds up part of the time and slows down part of the time.
4. moves at a constant velocity.

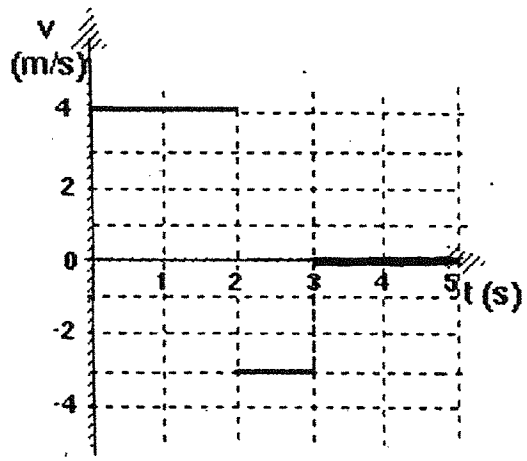
The graph shows position as a function of time for two trains running on parallel tracks. Which is true:




1. At time $t_B$, both trains have the same velocity.
2. Both trains speed up all the time.
3. Both trains have the same velocity at some time before $t_B$.
4. Somewhere on the graph, both trains have the same acceleration.

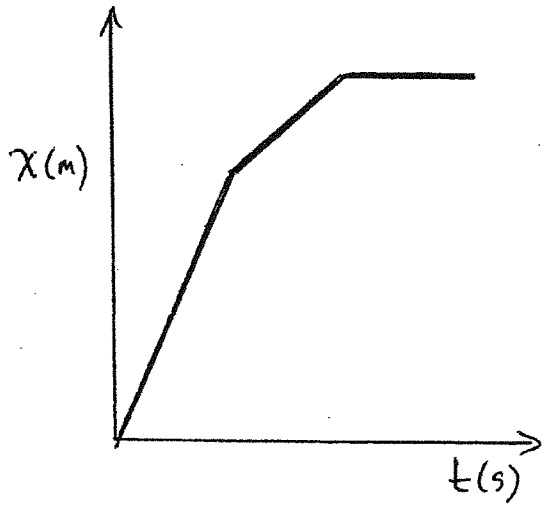
Pi

Look at the speed-time graph below:

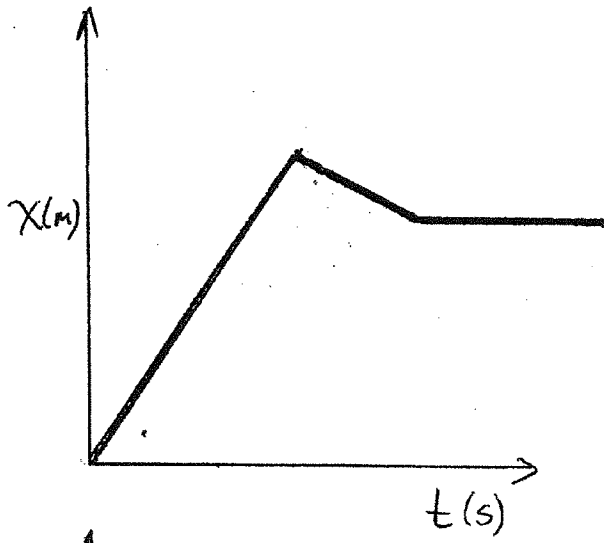



Which of the following position-time graphs best represents the speed-time graph above?

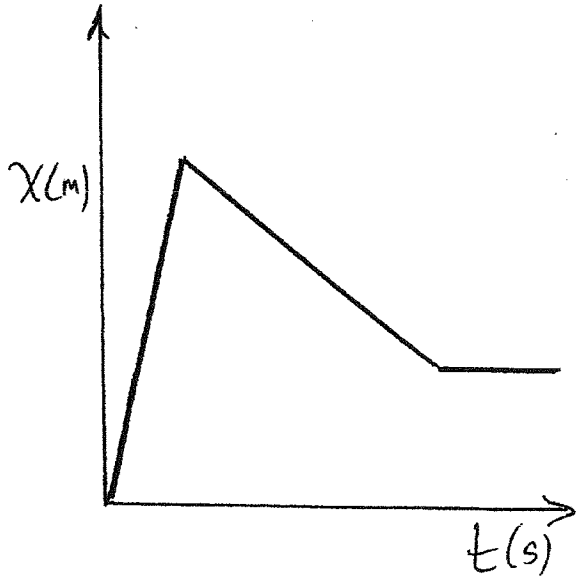
1.



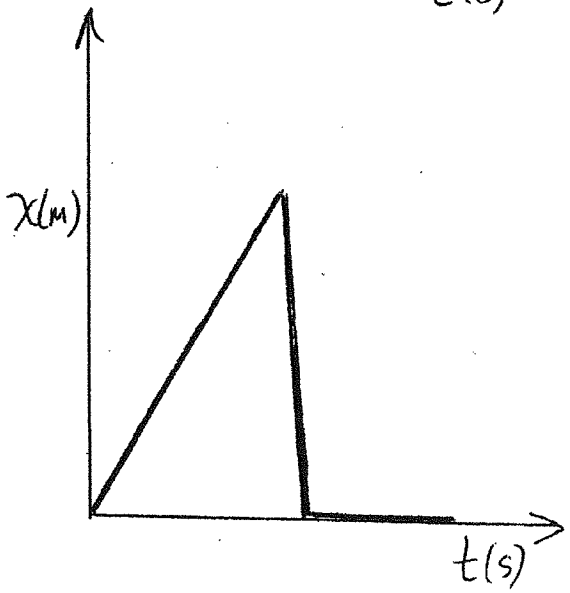

2.



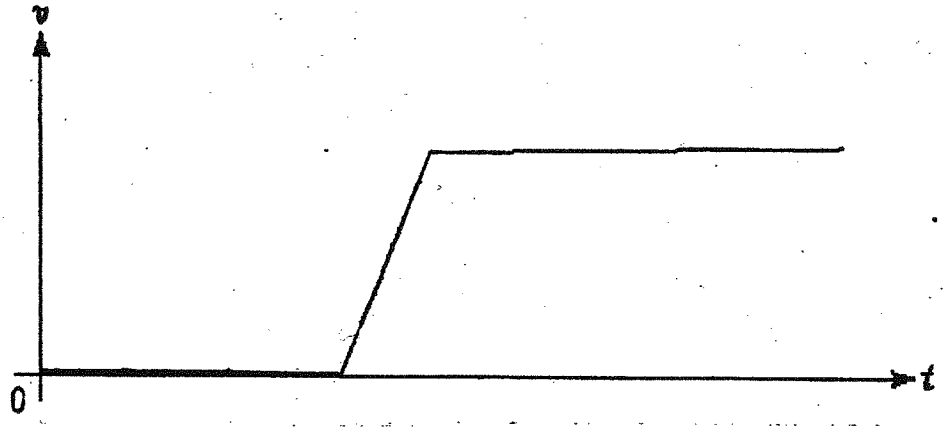

3.




4.

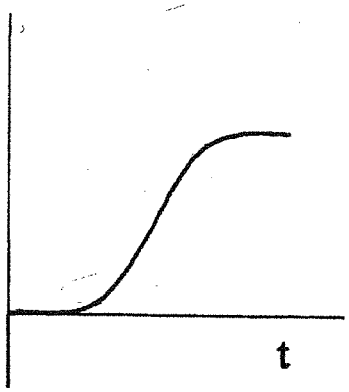


An air track cart initially at rest is put in motion when a compressed spring is released and pushes the cart. The *v* versus *t* graph is shown below.

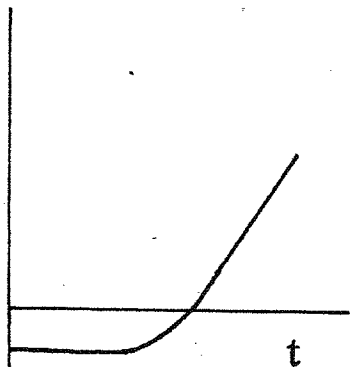



Which of the following best represents the *d* versus *t* graph?

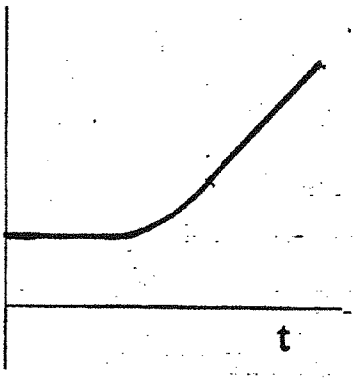
1.



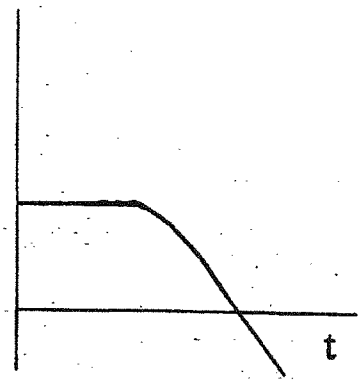

2.



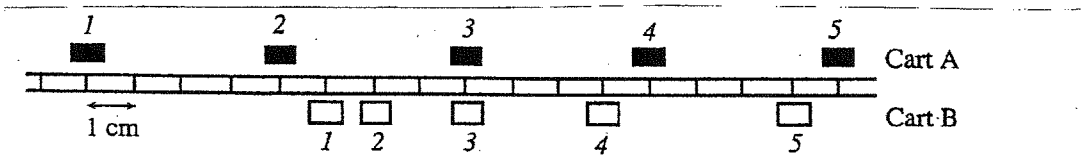

3.




4.



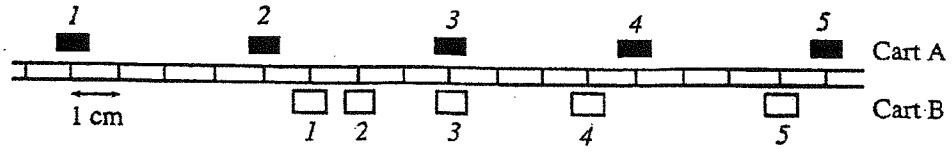
Cars A and B move along a horizontal track. The strobe diagram shows the locations of the cars at instants 1-5, separated by equal time intervals.




At instant 3

1. Car A and B have the same speed
2. Car A has a constant speed and car B is slowing down
3. Car A has a constant speed and car B is speeding up
4. From instant 3 to instant 4, car B has a greater speed than A

Cars A and B move along a horizontal track. The strobe diagram shows the locations of the cars at instants 1-5, separated by equal time intervals.




Do the two cars ever have the same speed?

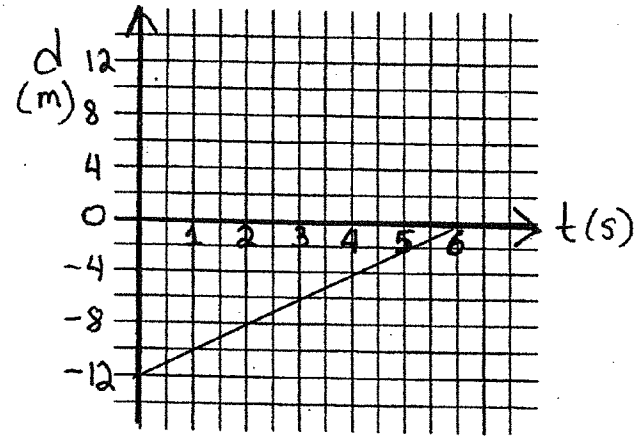
1. Yes, between instant 1 and instant 2
2. Yes, between instant 2 and instant 3
3. Yes, between instant 3 and instant 4
4. Yes, between instant 4 and instant 5
5. No, they never have the same speed

Below is an equation of position as a function of time:

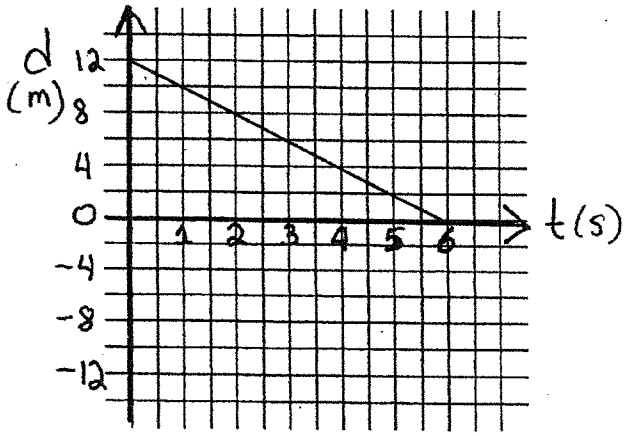
$$d = (-2\text{m/s})t + 12\text{m}$$

Which of the following graphs best represents the equation?

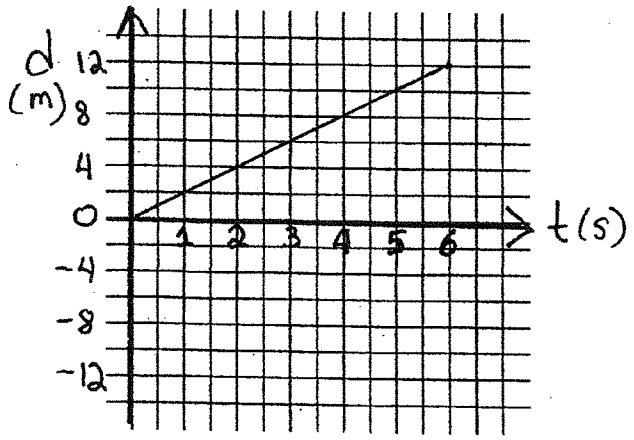
1.



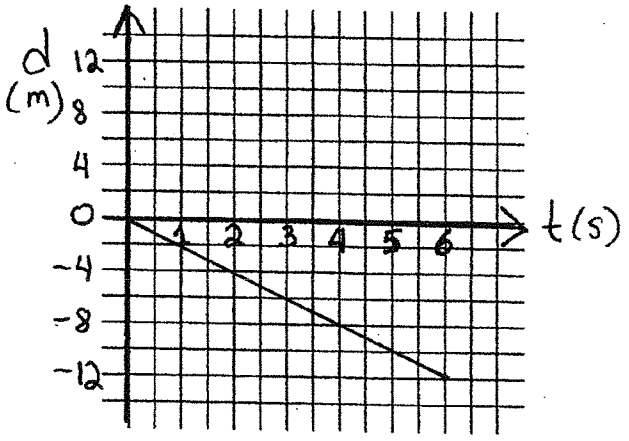

2.




3.

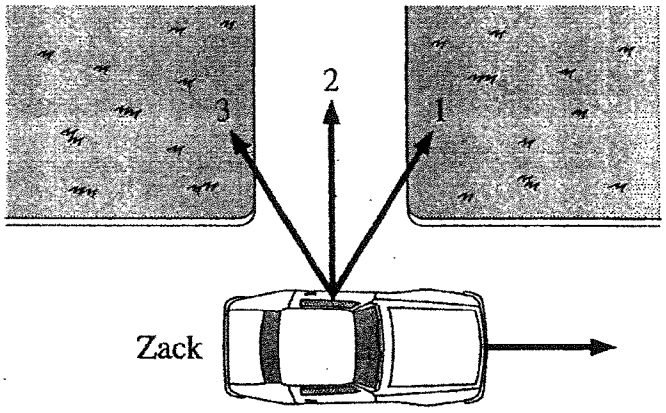



4.



Zack is driving past his house. He wants to toss his physics book out the window and have it land in his driveway. If he lets go of the book exactly as he passes the end of the driveway, which way should he throw the book?

1) throw 1
2) throw 2
3) throw 3



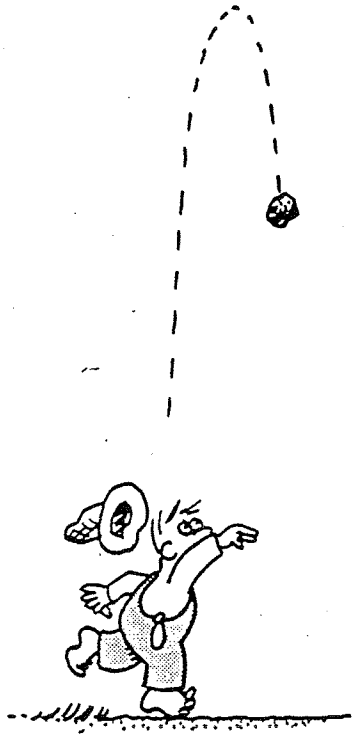
A stone is thrown straight upward and at the very top of its path its velocity is momentarily zero. What is the acceleration at this point?

1) zero

2) 9.8 $m/s^2$

3) greater than zero, but less than 9.8 $m/s^2$

4) greater than 9.8 $m/s^2$



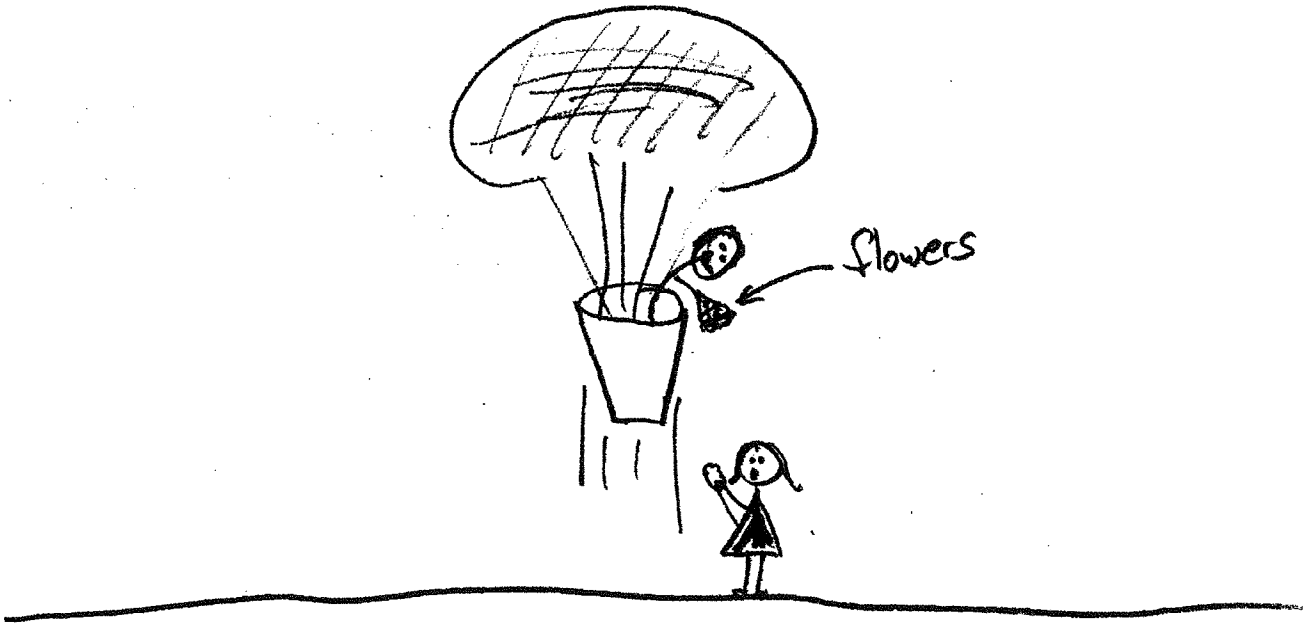
If you drop an object in the absence of air resistance, it accelerates downward at 9.8 $m/s^2$. If instead you throw it downward, its downward acceleration after release is

1. less than 9.8 $m/s^2$.
2. 9.8 $m/s^2$.
3. more than 9.8 $m/s^2$.

A person standing at the edge of a cliff throws one ball straight up and another ball straight down at the same initial speed. Neglecting air resistance, the ball to hit the ground below the cliff with the greater speed is the one initially thrown

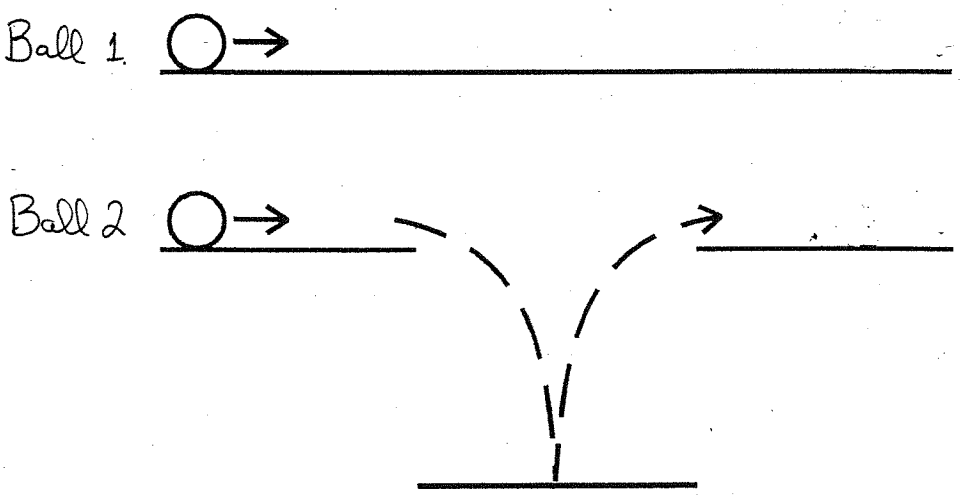
1. upward.
2. downward.
3. neither—they both hit at the same speed.

Romeo is in a hot air balloon rising with a constant velocity $v$ while below Juliet waves goodbye. Romeo then leans over the edge of the balloon and drops a bouquet of flowers to his love. According to Juliet, which of the following is true about the bouquet of flowers at the instant it is released by Romeo?




1. Its velocity is zero and its acceleration is zero
2. Its velocity is $v$ and it acceleration is zero
3. Its velocity is $-v$ and its acceleration is $-9.8\ m/s^2$
4. Its velocity is $v$ and its acceleration is $-9.8\ m/s^2$
5. Its velocity is zero and its acceleration is $-9.8\ m/s^2$

Two balls, starting at the same position, are travelling at the same constant speed along two separate level tracks. Ball 1 travels along the straight track shown while ball 2 travels straight then is allowed to fall, bounce off the ground, and back to the track again. Which ball reaches the end of the track first?



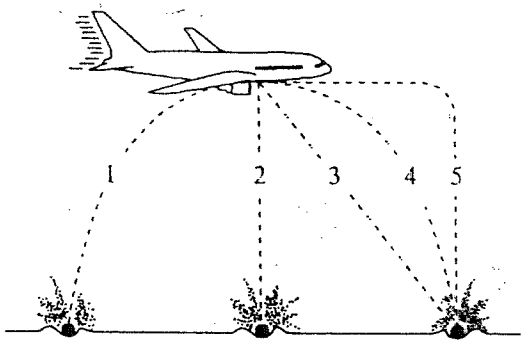

1. Ball 1
2. Ball 2
3. Both reach the end at the same time
4. Not enough information given

At the same time that a high speed bullet is fired horizontally from a rifle, another bullet is simply dropped from the same height. Which bullet strikes the ground first?

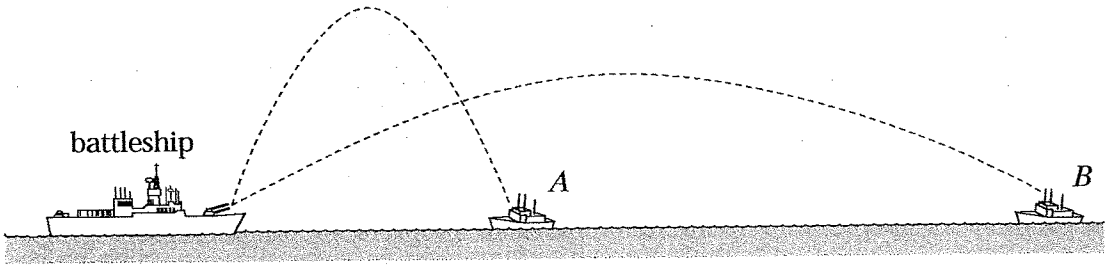
1) The dropped bullet
2) The fired bullet
3) Both strike at the same time
4) It will depend on the initial height of both bullets

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

As observed by a person standing on the ground and viewing the plane as in the figure below, which of the paths 1–5 would the bowling ball most closely follow after leaving the airplane?

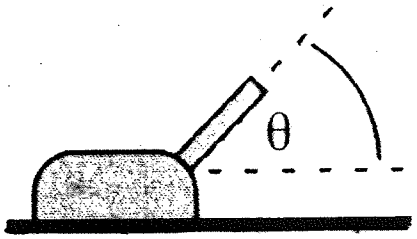


A battleship simultaneously fires two shells at enemy ships. If the shells follow the parabolic trajectories shown, which ship gets hit first?



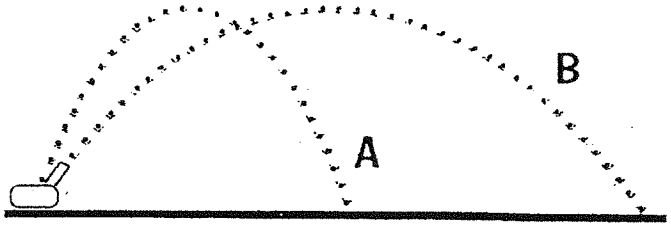

1. *A*
2. both at the same time
3. *B*
4. need more information

At what angle above the horizontal should a cannon fire so that the shell lands as far as possible from where it is fired?



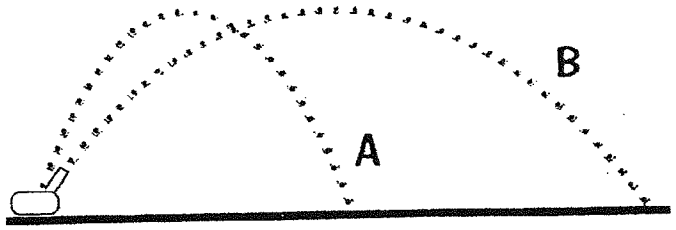

1) much greater than 45°
2) slightly over 45°
3) exactly 45°
4) slightly under 45°
5) much less than 45°

A cannon shoots two cannon balls, A and B, at the same time as shown below. The maximum altitudes of both trajectories are the same, but the horizontal distance of B is about twice that of A. Which ball is in the air longer?



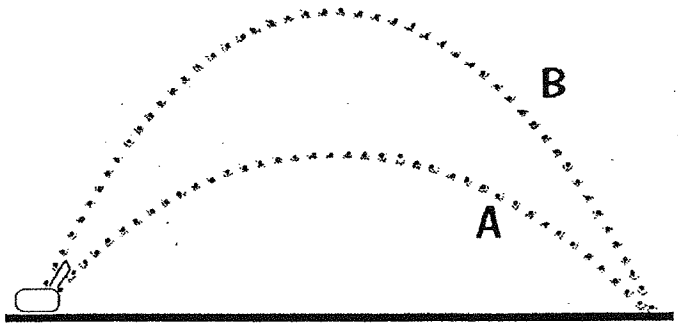

1. A
2. B
3. Both the same time
4. Not enough information given

A cannon shoots two cannon balls, A and B, at the same time as shown below. The maximum altitudes of both trajectories are the same, but the horizontal distance of B is about twice that of A. Which ball is moving faster just after being fired by the cannon?



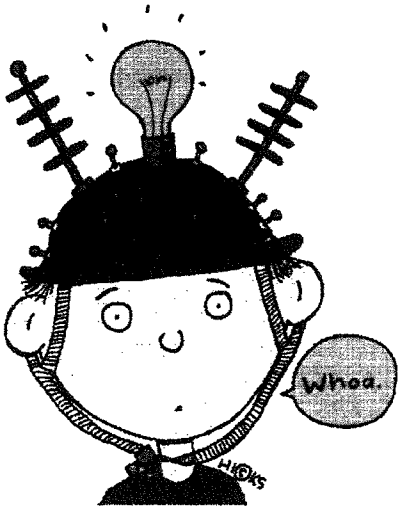

1. A
2. B
3. Both the same speed
4. Not enough information given

A cannon shoots two cannon balls, A and B, at the same time as shown below. The horizontal trajectories are the same, but the maximum altitude of B is about twice that of A. Which ball is traveling faster horizontally at the beginning of its trajectory?




1. A
2. B
3. Both the same speed
4. Not enough information given

If an object is moving at a constant velocity then there must be a force acting in the direction of the motion.



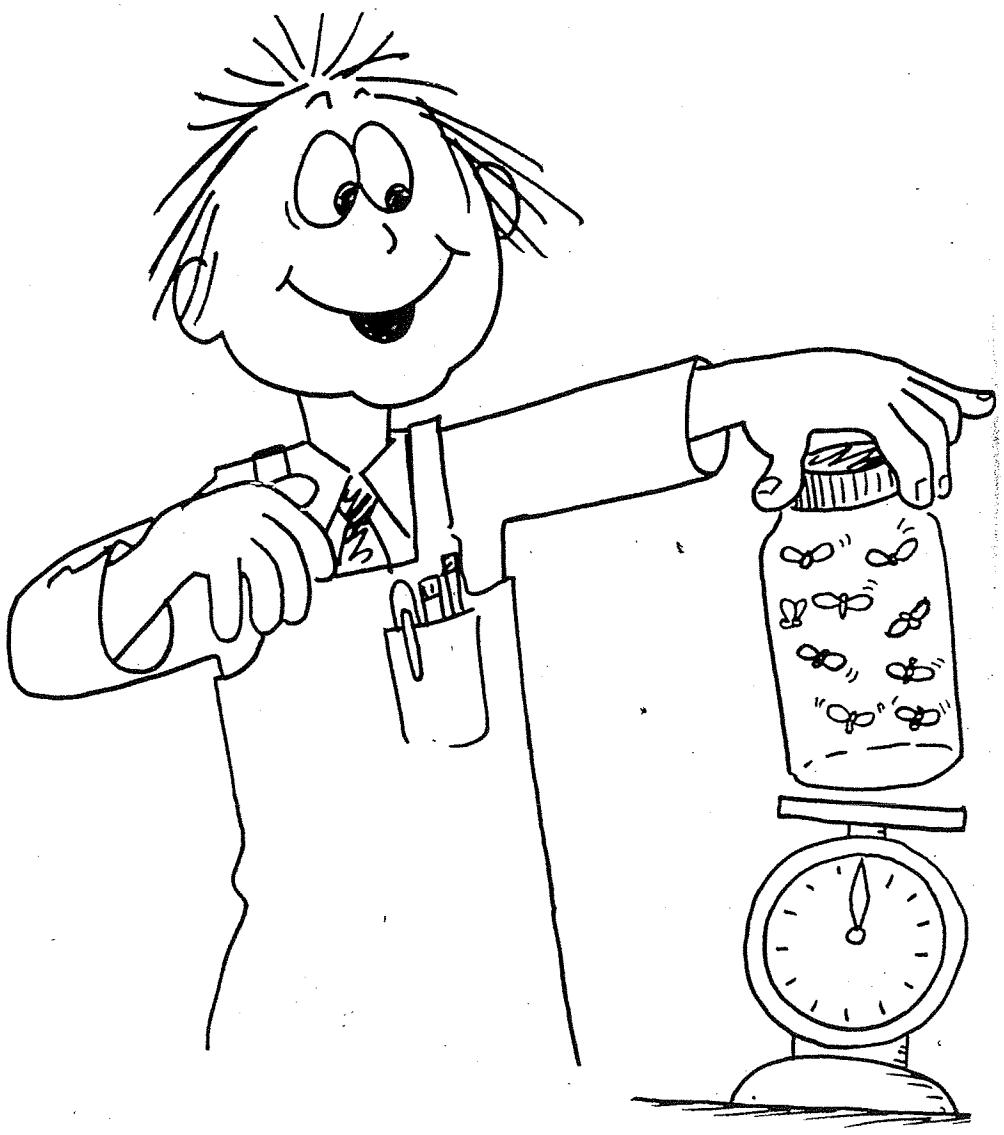

1) True
2) False

A rear end collision between a soft drink truck and a car occurs. When the police arrive the truck driver claims the car backed into the front of the truck. The car driver claims that the front of the truck hit her from behind. The only evidence is number of soft drink bottles fell forward into the truck driver's seat during the collision. Who is at fault?

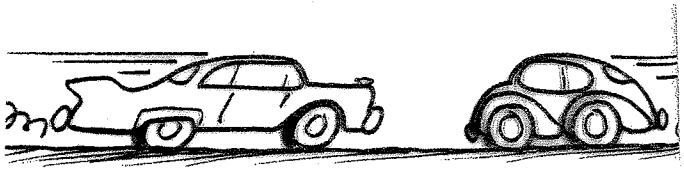
1. The car driver
2. The truck driver
3. Unable to determine who was at fault

A bunch of flies are capped in a jar. You place the jar on a scale. The scale will register most weight when the flies are

1) sitting on the bottom of the jar
2) flying around inside the jar
3)... weight of the jar is the same in both cases



If a Cadillac car and a Volkswagen car have a head-on collision, which car will experience the greatest impact force?

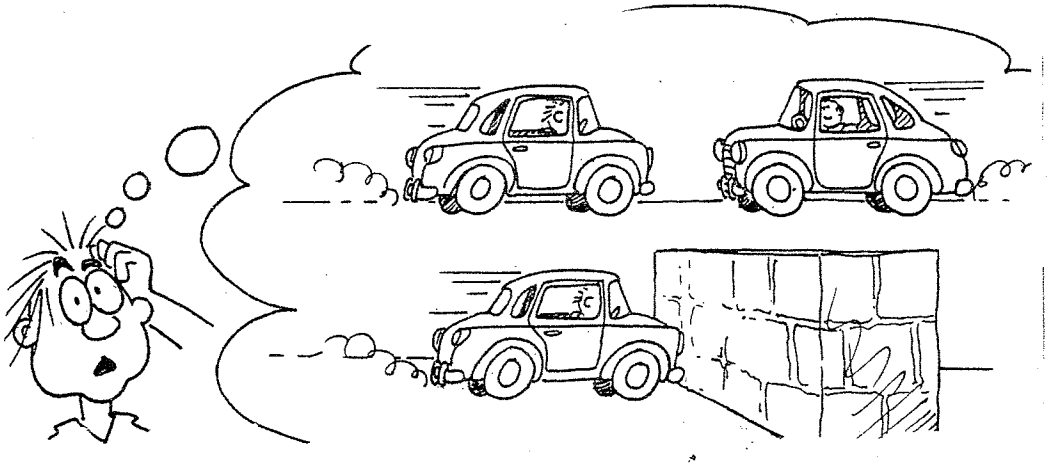


a) The Cadillac
b) The Volkswagen
c) Both the same

You are driving down the highway and a bug splatters on your windshield. Which experiences the greater force?

1. The bug
2. The windshield
3. They experience the same force
4. Not enough information given

Consider the consequences of driving a car into a head-on collision with an identical car travelling toward you at the same speed as opposed to colliding at the same speed against a massive concrete wall. Which of these two situations would result in the greatest impact force?

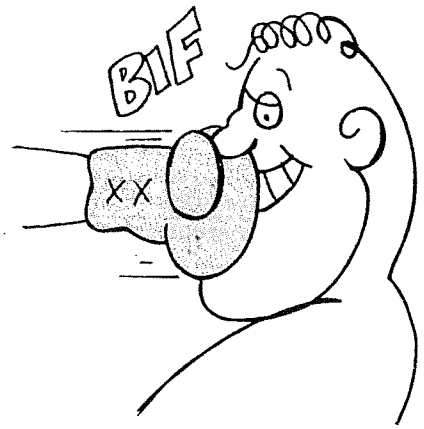


a) Colliding with the approaching car
b) Colliding with the massive stationary wall
c) Both would have the same impact force

Drop a 1 kg rock from the leaning tower of Pisa and the earth pulls it with a force of 9.8 N. The rock pulls on the earth with a force of


1) An incredibly small force to low to measure
2) A force between 0 and 9.8 N but measurable
3) A force equal to 9.8 N
4) A force greater than 9.8N

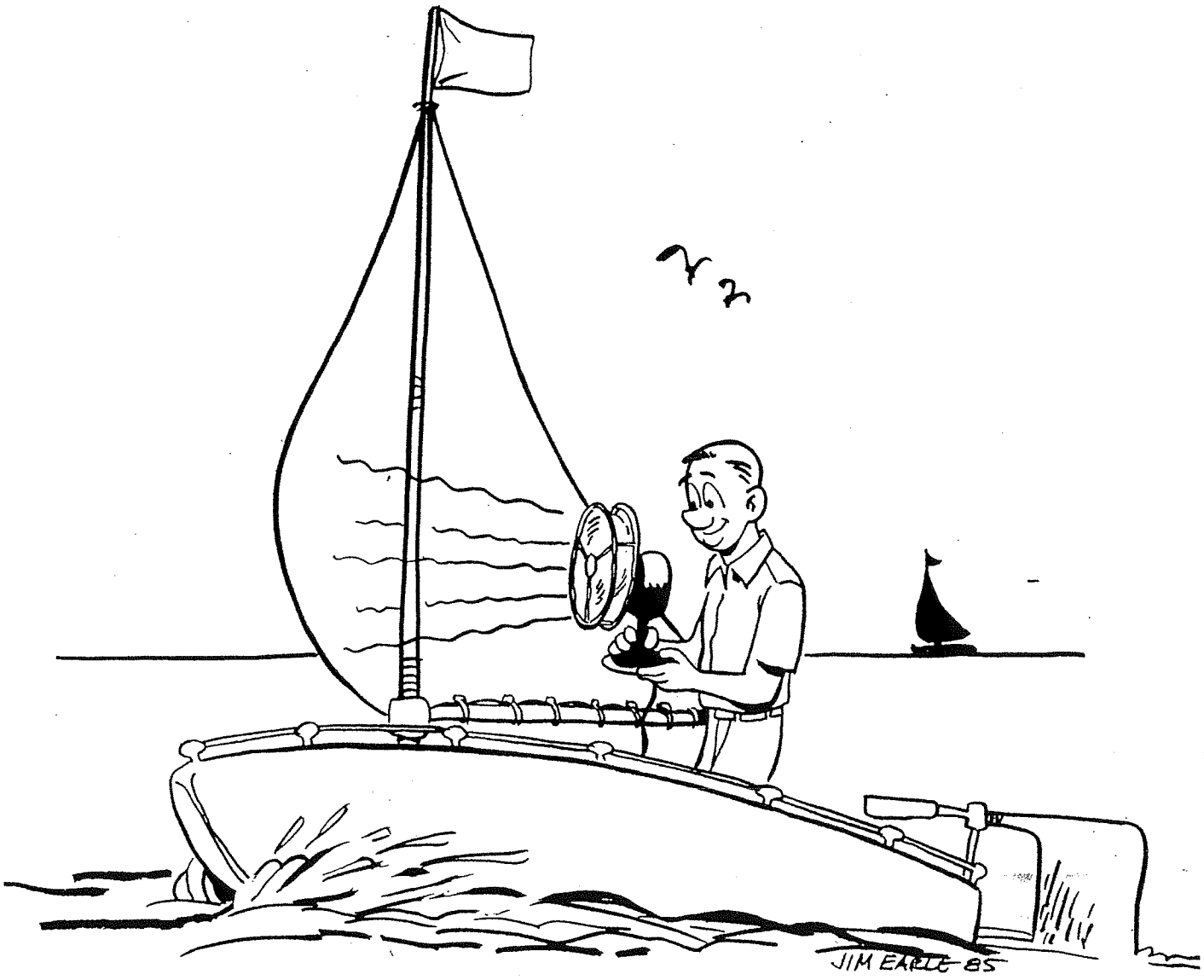
A boxer is in an unfortunate position to receive a punch. Skillfully, the boxer moves his head back just in time such that the force applied is much less than expected. Which of the following best describes the forces involved?




1) Force by the hand on the face is greater than the force by the face on the hand
2) Force by the face on the hand is equal to the force by the hand on the face
3) Force by the hand on the face is less than the force by the face on the hand
4) Not enough information is given

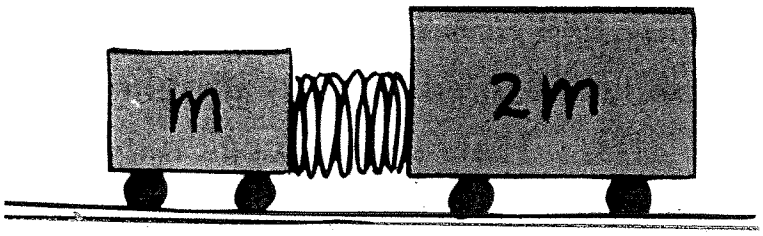
A man holds onto a fan while in a boat shown below. Does the sailboat work better with the fan?

1. Yes, it will go
2. It will move if there is no friction
3. It will not go

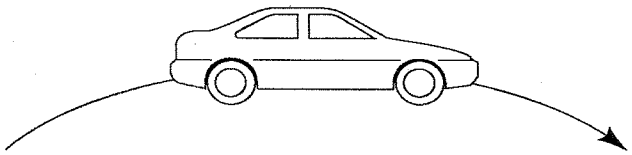


Suppose two carts, one twice as massive as the other, fly apart when the compressed spring that joins them is released. Which of the following statements is true?

1) Force by lighter cart on heavier cart is ½ the force by heavier cart on lighter cart?
2) Force by heavier cart on lighter cart is twice the force by lighter cart on heavier cart?
3) Force by lighter cart on heavier cart is smaller than the force by heavier cart on lighter cart but not necessarily by ½.
4) Force by heavier cart on lighter cart is larger than the force by lighter cart on heavier cart but not necessarily twice the amount
5) None of the above



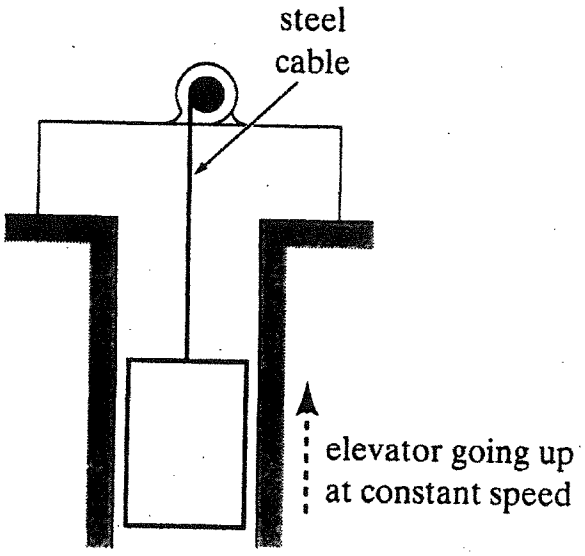
A car rounds a curve while maintaining a constant speed. Is there a net force on the car as it rounds the curve?



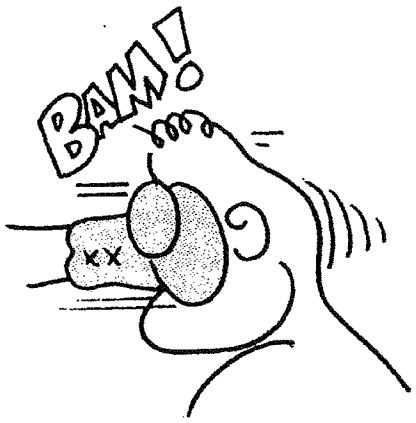
1. No—its speed is constant.
2. Yes.
3. It depends on the sharpness of the curve and the speed of the car.

An elevator is being lifted up an elevator shaft at a constant speed by a steel cable as shown in the following figure. All frictional effects are negligible. In this situation, forces on the elevator are such that

1. the upward force by the cable is greater than the downward force of gravity.
2. the upward force by the cable is equal to the downward force of gravity.
3. the upward force by the cable is smaller than the downward force of gravity.
4. the upward force by the cable is greater than the sum of the downward force of gravity and a downward force due to the air.
5. none of the above. (The elevator goes up because the cable is being shortened, not because an upward force is exerted on the elevator by the cable).

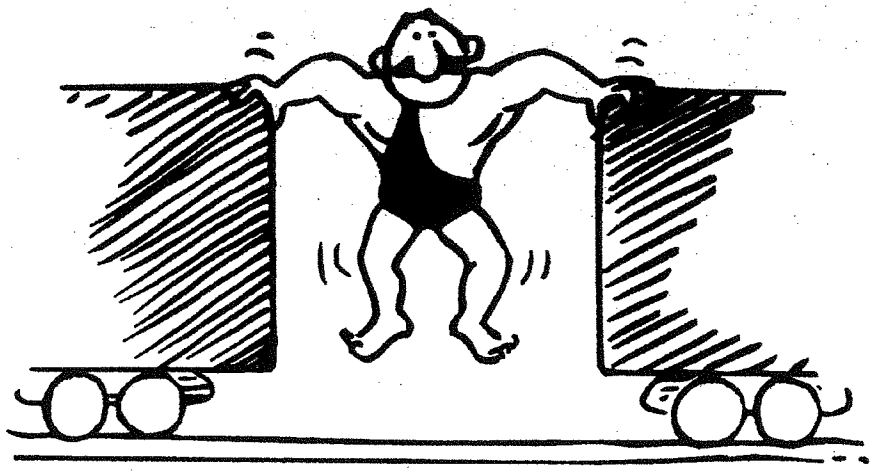


The boxer is was not so skillful the second time! Now the boxer receives the full force of the punch to the face. Which of the following best describes the forces involved this time?




1) Force by the hand on the face is greater than the force by the face on the hand
2) Force by the face on the hand is equal to the force by the hand on the face
3) Force by the hand on the face is less than the force by the face on the hand
4) Not enough information is given

The strong man in the figure below will push two initially stationary freight cars of equal mass apart before he himself drops straight to the ground. Is it possible for him to give either of the cars a greater speed than the other?

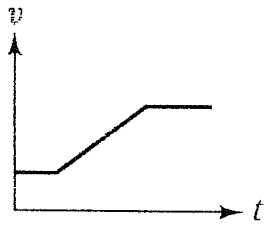


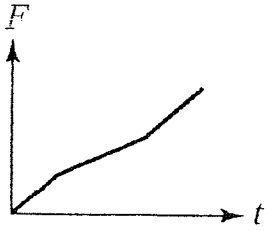
1) Yes
2) No

Magnet A has twice the magnetic field strength of magnet B and at a certain distance pulls on magnet B with a force of 50 N. With how much force, then, does magnet B pull on magnet A?

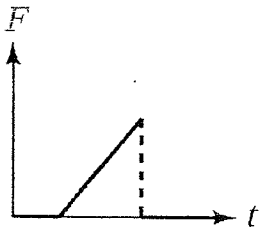
1) 25 N
2) 50 N
3) 75 N
4) 100 N

The velocity of a Dodge Colt as a function of time is shown in the following graph. Which of the graphs 1-5 best represents the net force vs. time for the Colt?

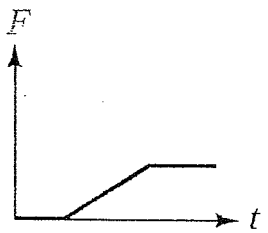


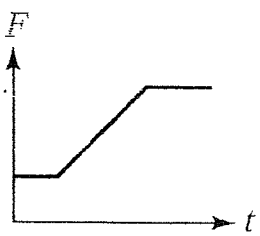

1



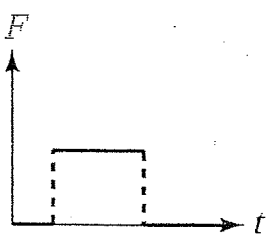

2




3




4

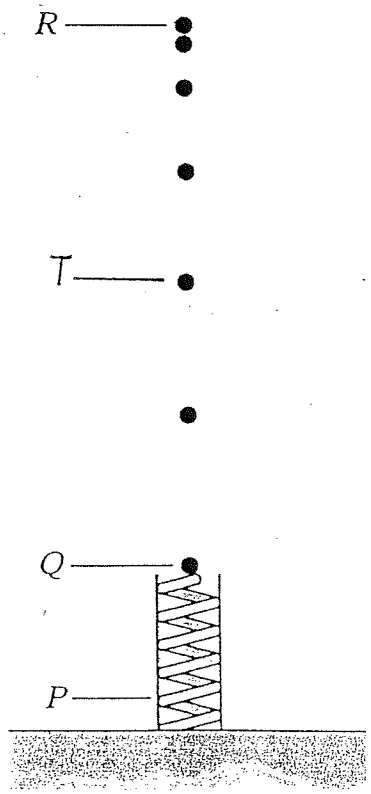



5

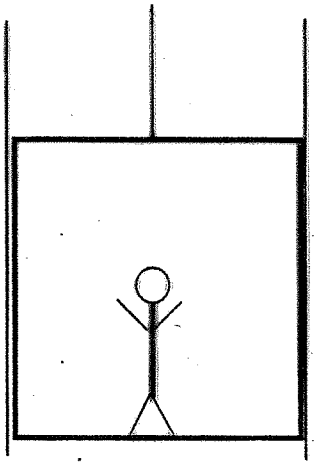
The figure below represents a multi flash photograph of a small ball being shot straight up by a spring. The spring, with the ball atop, was initially compressed to the point marked *P* and released. The ball is still in contact with the spring at the point marked *Q*, and reaches its highest point at the point marked *R*. Neglect air resistance.

Which of the following statements is true about the ball at point *T*?

1) No forces are acting on the ball at *T* as it moves upwards
2) The force by the spring on the ball is gradually decreasing from *Q* to *T*
3) Only the force of gravity acts on the ball at *T*
4) The force by the spring on the ball and the force due to gravity act on the ball at *T*
5) None of the above



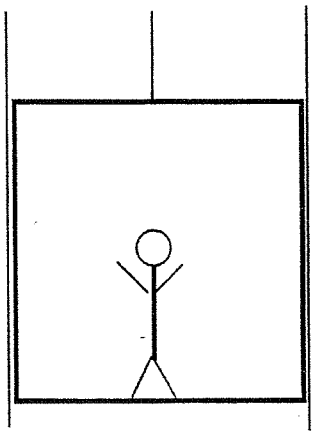
Consider a person standing in an elevator that is moving up at a constant velocity. The upward normal force $N$ exerted by the elevator floor on the person is



1. larger than
2. identical to
3. smaller than

the downward weight $W$ of the person.

Consider a person standing in an elevator that is accelerating upward. The upward normal force $N$ exerted by the elevator floor on the person is

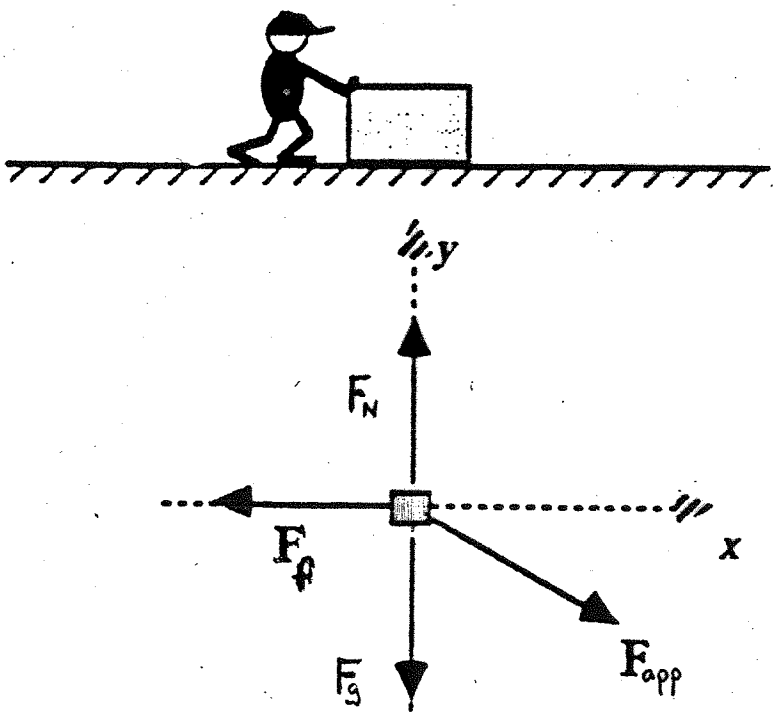


1. larger than
2. identical to
3. smaller than

the downward weight $W$ of the person.

A person pushes a crate so that it moves at constant velocity toward the right. A free body diagram for the crate is shown below (the arrows are not necessarily the correct relative magnitudes). Which choice below best represents the relative magnitudes of the forces?

1. $F_{app} = F_f$ and $F_N = F_g$
2. $F_{app} = F_f$ and $F_N > F_g$
3. $F_{app} = F_f$ and $F_N < F_g$
4. $F_{app} > F_f$ and $F_N = F_g$
5. $F_{app} > F_f$ and $F_N > F_g$



Object one moves on a horizontal, frictionless surface at a constant velocity of magnitude 10 m/s. Object two of the same mass moves on the same surface at a constant velocity of magnitude 20 m/s. Compare the net force acting on each object.

1. $F_{net}$ (on one) > $F_{net}$ (on two)
2. $F_{net}$ (on one) < $F_{net}$ (on two)
3. $F_{net}$ (on one) = $F_{net}$ (on two) $\neq 0$
4. $F_{net}$ (on one) = $F_{net}$ (on two) = 0
5. Unknown

You are pushing a wooden crate across the floor at constant speed. You decide to turn the crate on end, reducing by half the surface area in contact with the floor. In the new orientation, to push the same crate across the same floor with the same speed, the force that you apply must be about

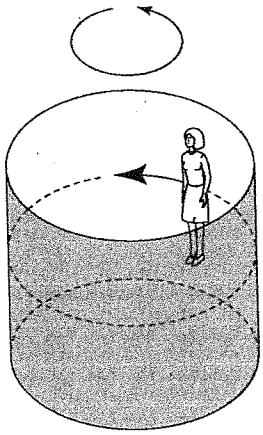
1. four times as great
2. twice as great
3. equally great
4. half as great
5. one-fourth as great

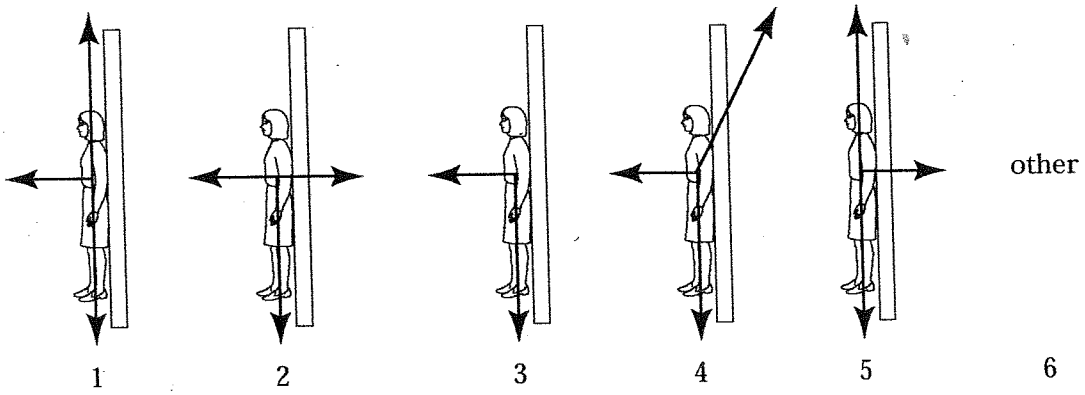
as the force required before you changed the crate's orientation.

You are a passenger in a car and not wearing your seat belt. Without increasing or decreasing its speed, the car makes a sharp left turn, and you find yourself colliding with the right-hand door. Which is the correct analysis of the situation?

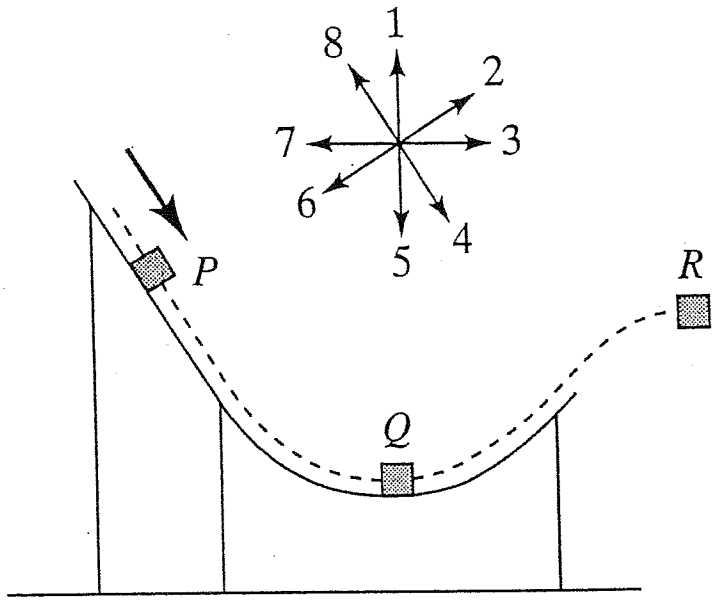
1. Before and after the collision, there is a rightward force pushing you into the door.
2. Starting at the time of collision, the door exerts a leftward force on you.
3. both of the above
4. neither of the above

A rider in a "barrel of fun" finds herself stuck with her back to the wall. Which diagram correctly shows the forces acting on her?





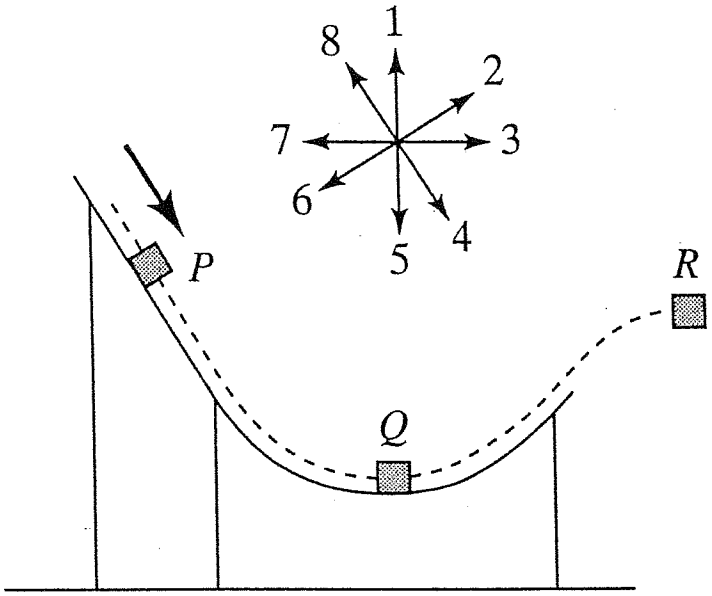
The diagram below depicts a block sliding along a frictionless ramp. The eight numbered arrows represent directions of the net force acting on the block.




The direction of the net force, when at position *Q*, is best represented by which of the arrows in the diagram?

1. Arrow 1
2. Arrow 3
3. Arrow 5
4. Arrow 7
5. None of the arrows. Net force is zero.

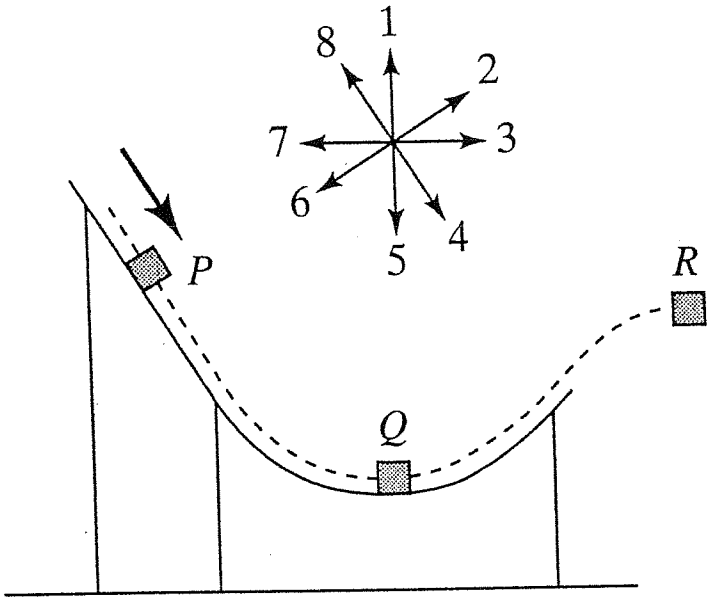
The diagram below depicts a block sliding along a frictionless ramp. The eight numbered arrows represent directions of the net force acting on the block.




The direction of the net force, when at position *P*, is best represented by which of the arrows in the diagram?

1. Arrow 1
2. Arrow 2
3. Arrow 3
4. Arrow 4
5. None of the arrows. Net force is zero.

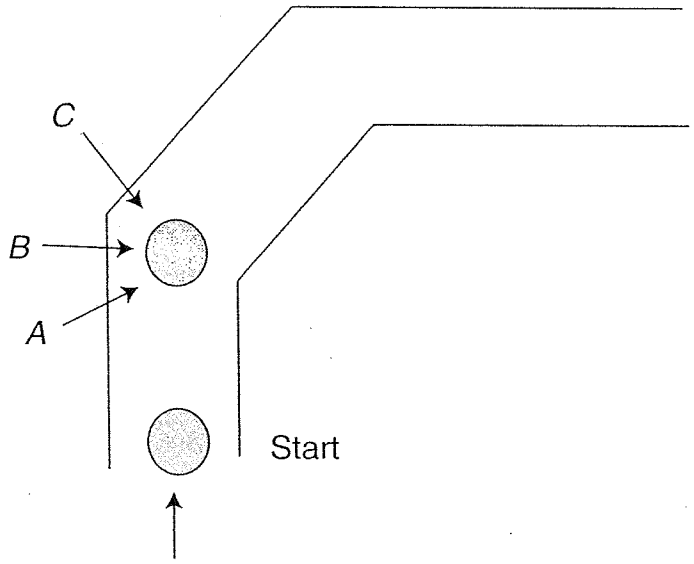
The diagram below depicts a block sliding along a frictionless ramp. The eight numbered arrows represent directions of the net force acting on the block.




The direction of the net force, when at position $R$, is best represented by which of the arrows in the diagram?

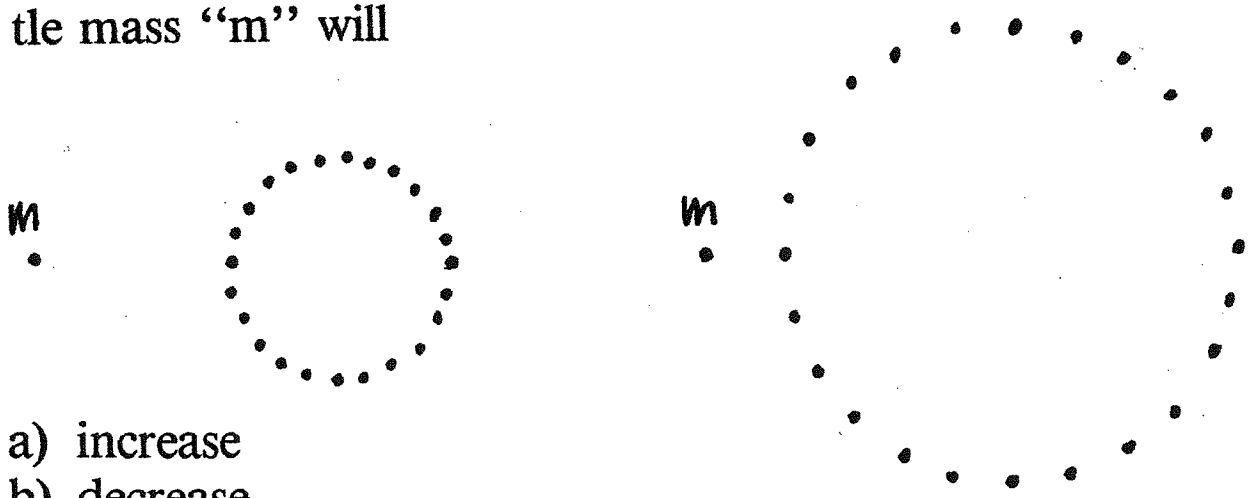
1. Arrow 1
2. Arrow 3
3. Arrow 5
4. Arrow 7
5. None of the arrows. Net force is zero.

Suppose that we are trying to get an ice hockey puck to travel along the track shown below. At the beginning of the track somebody hits the puck in the direction shown. (*Note*: Each hit of the puck has the same intensity) In which direction- *A*, *B*, or *C*- will somebody need to hit the puck so that it makes the first turn?



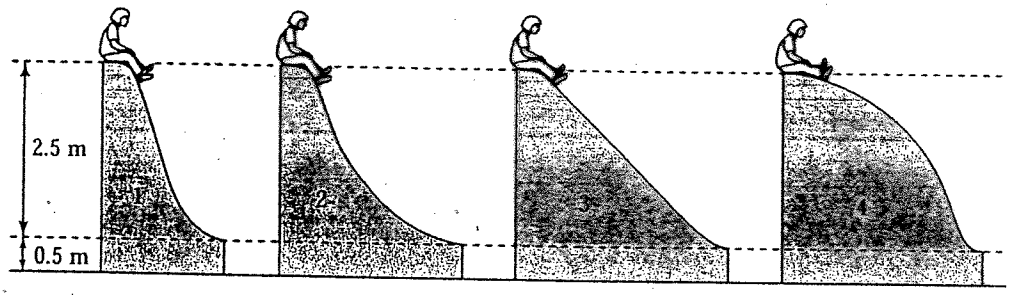
## NEWTON'S ENIGMA

This question troubled Newton for many years. A little mass, "m," is a certain distance from the center of a globular cluster of masses and there is a certain force of gravity, due to the cluster of masses, on the little mass that pulls it toward the center of the cluster. Now consider the situation whereby neither the little mass nor the center of the cluster moves, but the cluster uniformly expands. As a result of this expansion some parts of the globular cluster are closer to "m" and some are farther from "m." After the expansion, the forces of gravity of the cluster on the little mass "m" will




a) increase
b) decrease
c) remain unchanged

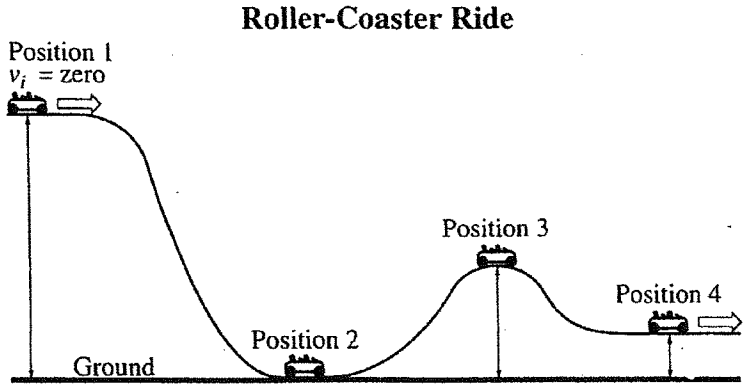
A young girl wishes to select one of the frictionless playground slides illustrated below to give her the greatest possible speed when she reaches the bottom of the slide.




Which of the slides should she choose?

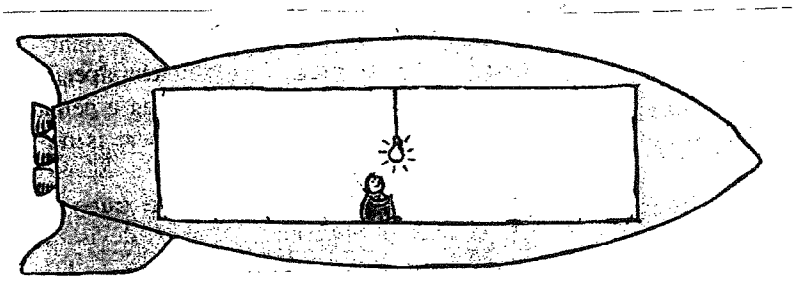
1. Slide 1
2. Slide 2
3. Slide 3
4. Slide 4
5. It doesn't matter, her speed would be the same for each slide.

A 250 kg roller coaster car starts at position 1 and continues through the entire track. Assume the frictional force is zero between positions 1 and 4. What is the order from the **greatest** amount of kinetic energy to the **least**, of the four different positions of the roller coaster?



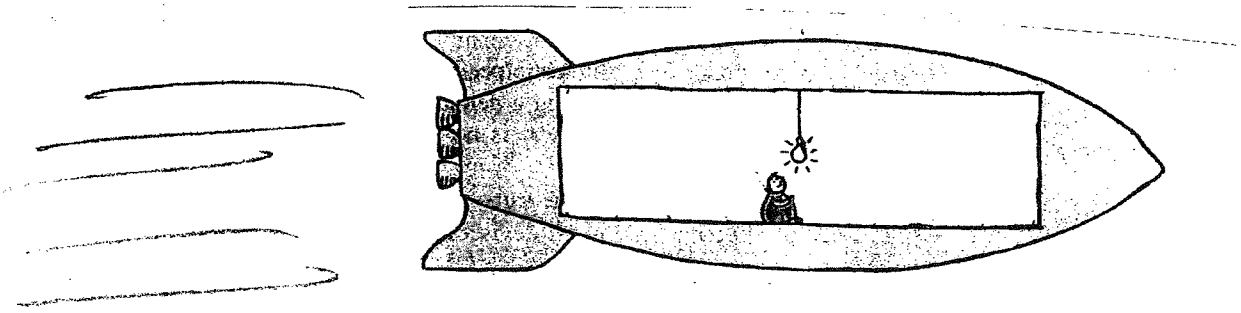

1) 1 2 3 4
2) 2 1 3 4
3) 4 3 2 1
4) 2 3 4 1
5) 2 4 3 1
6) None of the above

Suppose you are sitting in a rocketship that is at rest. In the exact middle of the rocketship compartment a light bulb flashes on. What do you see?



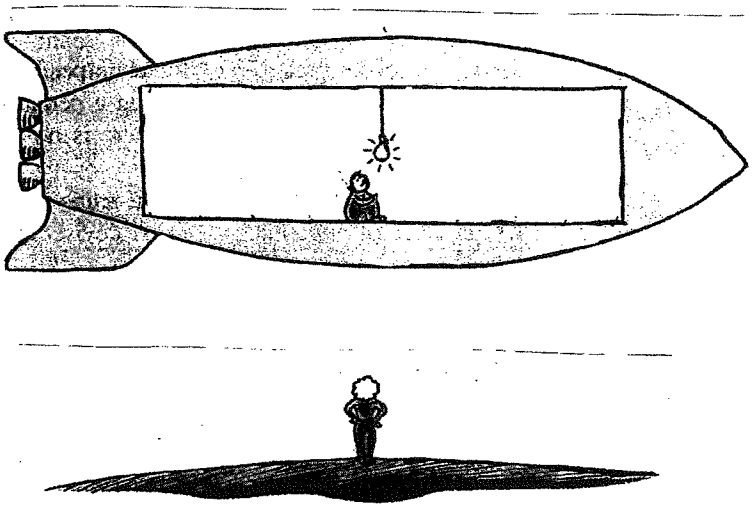
1. The light reaches the front of the compartment first
2. The light reaches the back of the compartment first
3. The light reaches the front and the back at the same time.

Suppose you are sitting in a rocketship that is moving at a very high speed. Again, in the exact middle of the rocketship compartment a light bulb flashes on. What do you see?



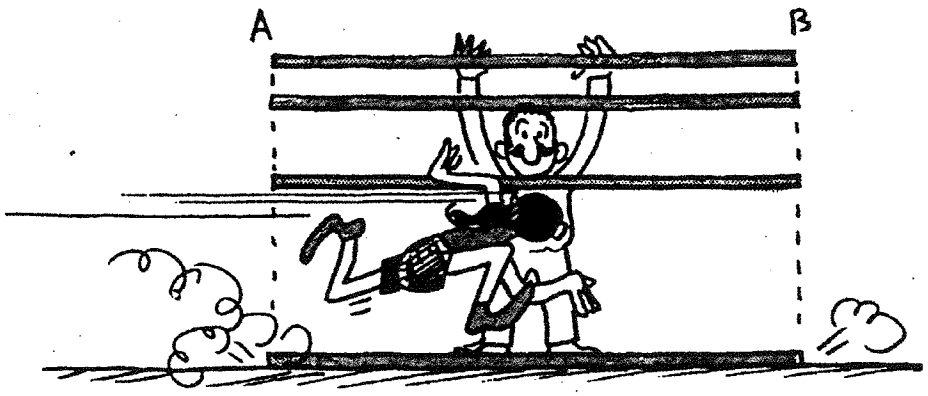
1. The light reaches the front of the compartment first
2. The light reaches the back of the compartment first
3. The light reaches the front and the back at the same time.

Your friend is watching the light flash as the rocketship passes her at a very high speed. What does your friend see?



1. The light reaches the front of the compartment first
2. The light reaches the back of the compartment first
3. The light reaches the front and the back at the same time.

You are standing near the middle of a long board which, as you perceive it, falls such that the two ends strike the ground simultaneously. You, therefore, think the board falls flat. But what does Ms. Bright, who is dashing by you near the speed of light, see?




1. The board falling flat.

2. End *B* striking the ground before end *A*.

3. End *A* striking the ground before end *B*.

**If you were traveling with respect to earth close to the speed of light in a space craft, you could detect it because**

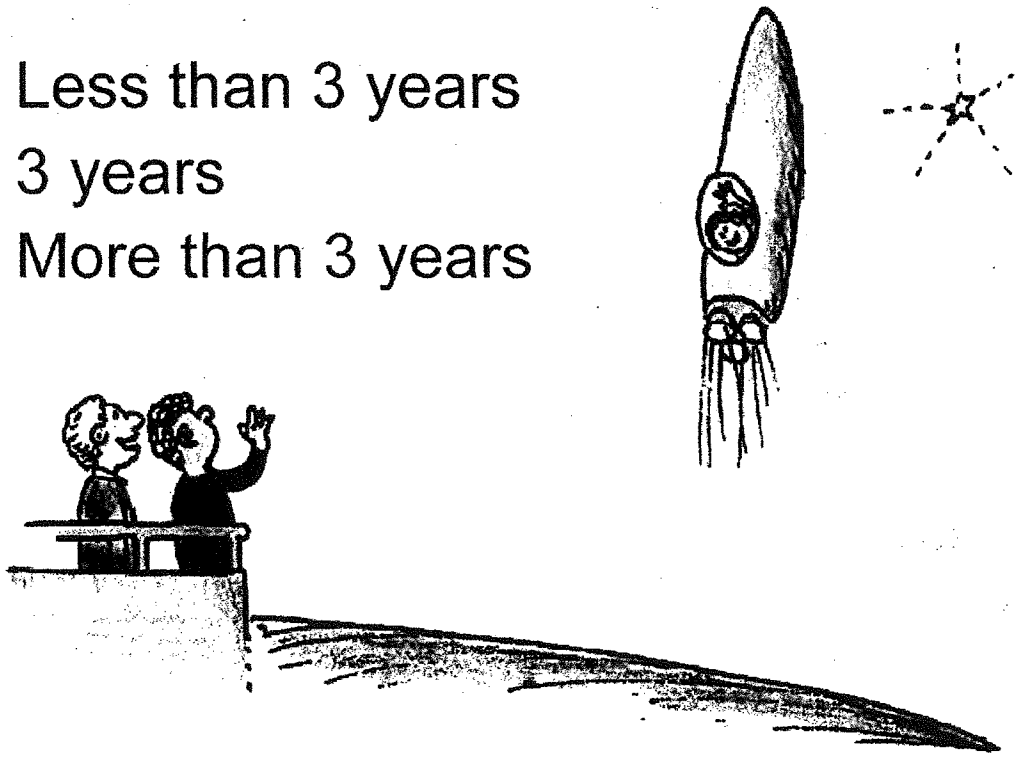
**1) Your heart would slow down**
**2) Your watch would tick slower**
**3) Or you could never tell your speed by changes in you**

**If you were traveling with respect to earth close to the speed of light in a space craft, what would the people on earth notice about you?**

**1) Your heart would slow down**
**2) Your heart would speed up**
**3) No change would be observed**

An astronaut ages 3 years when travelling at 99% the speed of light to the star Sirius and back. The space officials to greet her on her return age

1) Less than 3 years
2) 3 years
3) More than 3 years



A spear 10 metres long is thrown at relativistic speed through a pipe that is 10 m long. Both of these dimensions are measured when each is at rest. When the spear passes through the pipe, which of the following statements best describes what is observed?

1. The spear shrinks so that the pipe completely covers it at some point.

2. The pipe shrinks so that the spear extends from both ends at some point.

3. Both shrink equally so the pipe just covers the spear at some point.

4. Any of these, depending on the motion of the observer.

Chocolate chip cookie dough lies on a high speed conveyor belt which moves along at speed *v*. A circular stamp stamps out cookies as the dough is rushed by beneath it. When you buy these cookies in a store, what shape are they in?

1. Squashed in the direction of the moving belt
2. Stretched in the direction of the moving belt
3. Circular
4. Squashed perpendicular to the moving belt
5. Stretched perpendicular to the moving belt