PHYSICS QUESTIONS WITHOUT NUMBERS

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Introduction – the origins and intent of the questions

Physics without numbers?? Isn't this a contradiction in terms??

Certainly the way of knowing about the world that we label "physics" is characterized by precise relationships. For example, consider the relationship expressed as $\mathbf{F} \propto \mathbf{a}$. This is clearly *not* a relationship of the form 'there is a correlation of some form here'; it is rather 'the two variables are directly proportional, a causal link we know with certainty (given a set of limitations that we also know with certainty)'. And because of this physics is also characterized by precise measurements of variables and the search to measure variables with greater precision. One characterization of physics then could be the search for mathematically precise and casual relationships, and the then necessary search for more precise ways to measure relevant variables.

However, the learning and teaching of physics is another matter altogether. Over the last 40 years there has been an extraordinary number of research studies from every corner of the earth showing the dramatically inadequate learning that almost always comes from a singular focus on the mathematical relationships of physics. One individual prominent among these researchers, Reinders Duit from Germany, for many years maintained a bibliography of such research studies (see http://www.ipn.uni-kiel.de/aktuell/stcse/stcse.html to see this bibliography). By the time he retired and stopped collecting early in 2009, Duit had just under 8,500 studies listed, with about half of these being in areas of physics (mechanics, electricity, magnetism, light, sound, nuclear, etc, etc). All of these make very clear that it is extremely common for students who learn only how to solve standard numerical questions to still have very poor understanding of concepts at the end of all this endeavour.

An extremely common example of this involves kinematics. If students spend lots of time answering questions that require them to select from and then use one or more of the "equations of motion" ($\mathbf{v} = \mathbf{u} + \mathbf{at}$; $\mathbf{s} = \mathbf{ut} + \frac{1}{2}\mathbf{at}^2$; $\mathbf{s} = \frac{1}{2}[\mathbf{u} + \mathbf{v}]\mathbf{t}$; $\mathbf{v}^2 = \mathbf{u}^2 + 2\mathbf{as}$), and do no more than this, then many research studies show a very sad outcome for most of these students - - - they have a well developed capacity to answer numerical questions provided these are very similar to the standard ones on which they have spent so much time, but have no understanding of what, for example, acceleration actually is. This is not to say that there is anything wrong with numerical questions; it is just that they need to be supplemented with questions that probe understanding in a different way.

The solution to this problem is the obvious one – use a much wider range of teaching approaches (and a similarly wider range of assessment approaches so that more than plugging numbers in standard questions is rewarded – and seen by students to be rewarded). The material in this document is one form of approach. It origins go back nearly 30 years when we were both heavily involved in the research that was exploring students' conceptions and misconceptions in physics, and we were both closely involved with the Victorian state-wide examination for Physics at the end of Year 12. At that time we set ourselves the task of creating one "physics question without numbers" each day, something we kept up for a period of time (neither of us now has any memory of long that period was). Many of these questions came from

our various research studies (that is, they are, or are close, adaptations of questions one [or both] of us used in exploring students' conceptions). Many of the questions have also over time been used (and then perhaps refined a little) by Gunstone when working with pre-service physics teacher education students (graduates with physics majors undertaking a one year teacher education course). And yes, pretty much all the misconceptions found in senior high school students turn up among physics graduates, only the frequencies change.

Two questions in this collection involve extracts from published material – Qn M106, which uses an extract from a Year 11 Victorian physics textbook (and asks students to identify and correct the misconception that the textbook demonstrates), and Qn G2, which uses a letter to the editor of a journal (and asks students to extend the thinking shown in the letter). These are but two examples of a rich reservoir of potential "physics questions without numbers". In particular we acknowledge the huge set of possibilities for questions of the first form (find and correct the misconception in the textbook) that already are in print. Our enthusiasm for this form of question, and our realization of just how much textbook material there was to use in such questions, owes a lot to the late Mario Iona. Professor Iona was a university physicist for 50 years, the last 40 at the University of Denver until he retired in 1986. For 24 of those years he had a regular column in *The Physics Teacher* (the journal of the American Association of Physics Teachers) in which he laid out the errors and incorrect explanations and damaging confusions (and, at times, the utter and complete silliness) he found in school and undergraduate textbooks. This column is a rich source of extracts on which to base questions that are of the same format as Qn M106 (and so are too many science and physics textbooks in use today!).

Using the questions

As with all things that attempt to prod students to think, there are many ways to use these questions, for example

- in the same way as standard questions are used, in both diagnostic and formative tests
- for homework
- as a focus for discussion between students (in which case we strongly recommend giving some time for students to attempt the question individually before pairing/tripling etc them up to try to talk towards an agreed answer)
- as a focus for a whole class discussion (something that can be particularly valuable as a next step after small groups of students have come to an agreed answer to a question; this approach is used in the Conceptual Understanding in Physics materials, see http://www.education.monash.edu.au/research/groups/smte/projects/cups/)

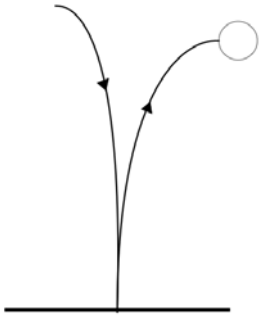
Many of the questions are suitable for all of these uses, while some are perhaps best used as bases for discussions (e.g. M55, M78, M79). But whatever the purpose, we commend questions without numbers as a means of promoting understanding of physics.

[We have formatted the file of questions so that no question runs over two pages, in an attempt to make its use as flexible as possible.]

Physics Questions Without Numbers

M: Mechanics and Heat

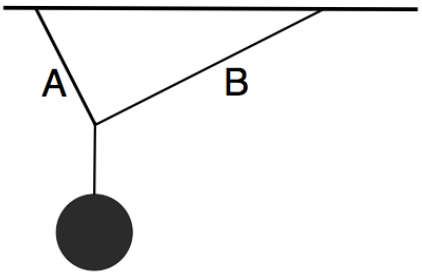
M1



A ball is bouncing on the floor.

The ball loses height at each bounce.
What energy changes are taking place?

M2

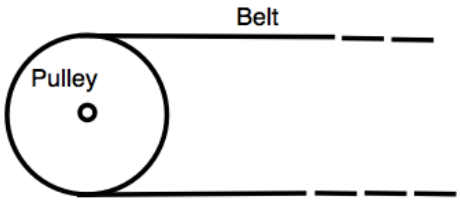


A large round ball is hanging from the ceiling, supported by two ropes A and B.
Is the tension in rope A

A: greater than
B: less than
C: the same as

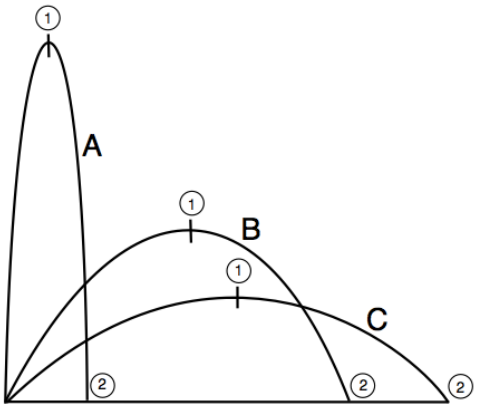
the tension in rope B?
Explain your answer.

M3



The diagram shows a pulley with a belt around it.
Draw and label arrows showing the directions of the forces put on the pulley by the belt, gravity, and the axle.

M4



Three projectiles, A, B, and C, are fired from the same machine on the moon with the same initial velocity.
Their paths are labelled A, B, and C.

At the three points marked 1, which projectile will have the greatest <u>kinetic energy</u>?
A or B or C, or will all be equal?
Explain your answer.

M5

At the three points marked 1, which projectile will have the greatest <u>total energy</u>?
A or B or C, or will all be equal?
Explain your answer.

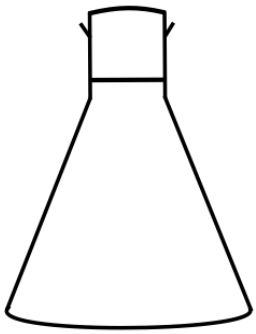
M6

At the three points marked 2, which projectile will have the greatest <u>kinetic energy</u>?
A or B or C, or will all be equal?
Explain your answer.

M7

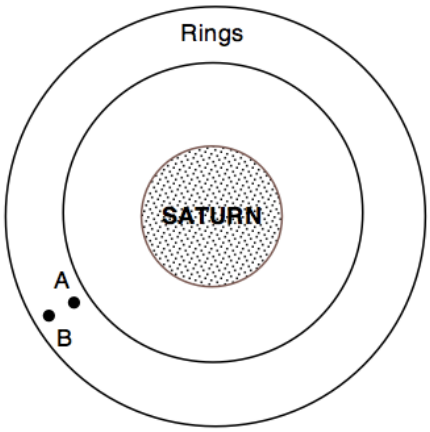
At the three points marked 2, which projectile will have the greatest <u>total energy</u>?
A or B or C, or will all be equal?
Explain your answer.

M8



The flask contains hydrogen gas.
(i) Draw dots in the flask to represent the hydrogen molecules and their positions in the flask.
(ii) Half the hydrogen gas is pumped OUT of the flask. Draw dots to represent the hydrogen molecules and their positions in the flask now.

M9



The diagram shows Saturn's ring system.
If the speed of a small rock at point A is compared with the speed of a small rock at point B, then the speed at A will be

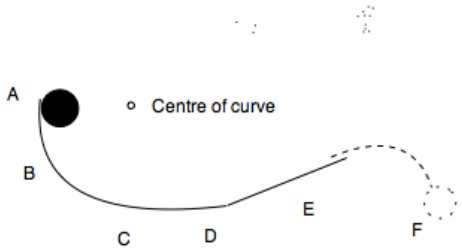
A: the same as at B
B: greater than at B
C: less than at B

M10

If through a collision the particle at A was slowed, it would

A: continue in the same orbit
B: spiral outward
C: spiral inward

M11



A ball rolls from point A down a section of circular track to a flat section then up a straight ramp.

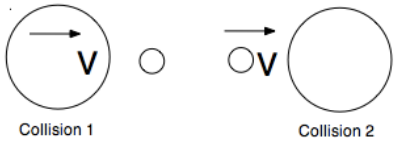
Sketch the graph of the magnitude of the ball's acceleration against time.

M12

Draw arrows at points A, B, C, D, E, and F to show the direction of the ball's acceleration at each point.

M13

In two different collisions a large mass M and a small mass m collide and stick together.
In the first collision the large mass was originally moving at speed V and the small mass was stationary.
In the second collision the small mass was originally moving at speed V and the big mass was stationary.



In which collision was there the greater change in kinetic energy? Explain your answer.

M14

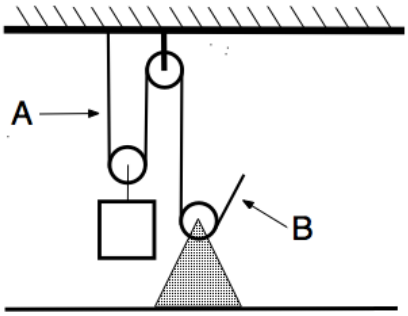
The same size force is put on two different masses for the same time.
Will the larger mass have a greater or smaller or the same velocity as the smaller one?

Will the larger mass have a greater or smaller or the same momentum as the smaller one?

Will the larger mass have a greater or smaller or the same kinetic energy as the smaller one?

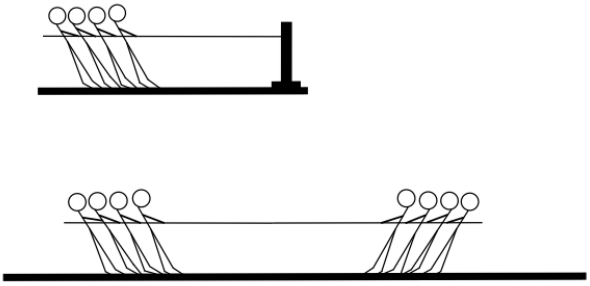
M15

A box hangs from a pulley that is free to move. One end of the rope the pulley hangs from is tied to a roof, the other passes over two fixed pulleys.



The tension in the rope at A is
A: greater than
B: less than
C: the same as
the tension at B?

M16



The tension in the rope in the bottom case is
A: greater than
B: the same as
C: less than
the tension in the top case.
Explain your answer

M17

When a ship sinks, does it go all the way to the bottom or does it stop part way down?
Explain why you think so.

M18

A small planet orbits a massive sun. The sun pulls on the planet with a gravitational force F.
The force that the planet puts on the sun is

A: F
B: much less than F
C: zero

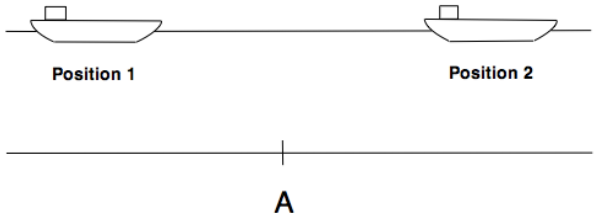
M19

"The gravitational force between two objects varies as $1/r^2$, where r is the distance between the centres of mass of the objects. Since the centre of mass of a horseshoe is outside the object, it is possible for r to be zero, and thus the force be equal to infinity."

Is there anything wrong with this argument? If so, what?

M20

A barge is moving along a canal.



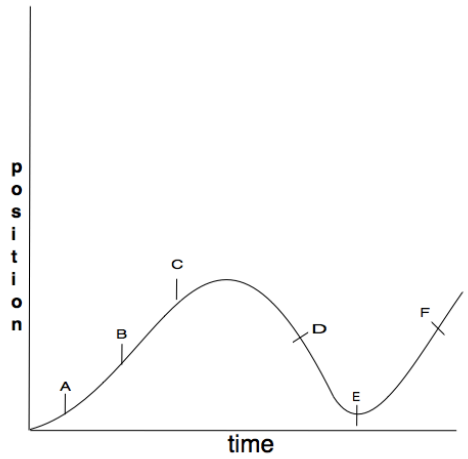
Draw a graph of the pressure at point A from the time that the barge is at position 1 to when it is at position 2.

M21

Two cars, A and B, are travelling on the same road. Car A is some distance behind car B. Both cars are going at steady speeds, though A is going faster than B.
What would you need to know to work out how long it would be before A catches up to B?

M 22

An object is moving as shown on this position-time graph.



At which point is the object's speed greatest?

At which point is the magnitude of the acceleration greatest?

At which points is the acceleration negative?

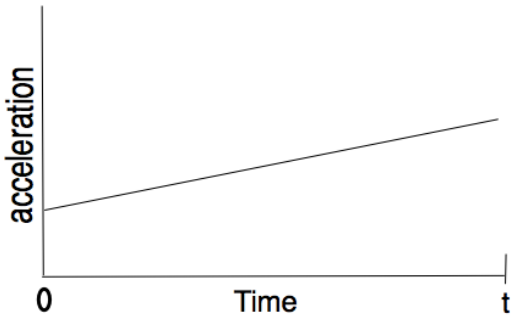
M23

Can you have two machines, one of which is stronger than the other, while the other is more powerful? Explain your answer.

M24

You compress a spring, so giving it potential energy. You put it between two bricks so that it cannot expand, then put it and the bricks in acid so that the spring is eaten away.
What happened to the potential energy?

M25

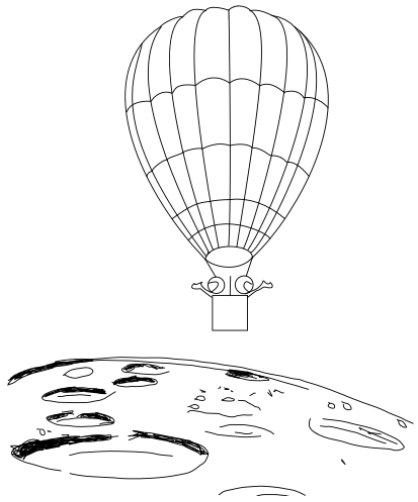


Here is an acceleration-time graph for an object.
What would you need to know to calculate the speed of the object at time t?

M26

A steel ball and a rubber ball are dropped from the same height on to a solid floor. The steel ball rebounds to a greater height than the rubber ball.
Which ball will have the greater change in temperature?

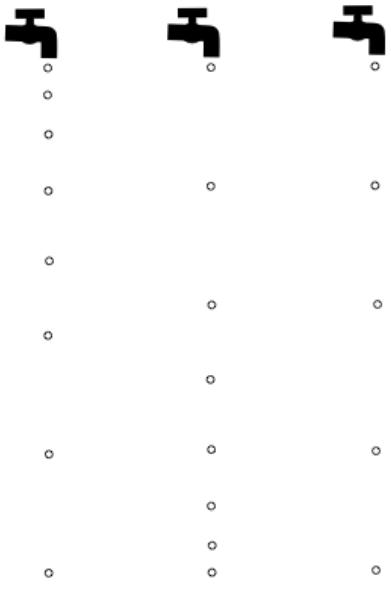
M27



The diagram shows astronauts drifting over the surface of the moon in a balloon.
What is wrong with this?

M28

Drops fall from a tap at a regular rate.



A **B** **C**

Which drawing shows the pattern of the drops at an instant?

M29

Mercury shrinks when it freezes. Will solid mercury float or sink in liquid mercury?

A: float
B: sink
C: more information is needed to answer the question

M30

A block of ice is floating in a glass of water. As the block melts will the water level rise, fall, or stay the same?

M31

A lump of solid lead is on the bottom of a crucible, beneath molten lead. The heat from the molten lead causes the solid lead to slowly melt. As it melts, will the level of the liquid lead rise, fall, or stay the same?
Explain your answer.

M32

Give an example of an object that is dense but light.

M33

Give an example of an object that is not dense but heavy.

M34

A man is standing in a stationary lift. His feet put a total force F on the floor of the lift. Say whether the force will be:
(a) equal to F
(b) greater than F
(c) less than F
for each of the following situations.

- **The lift is moving up at steady speed**
- **The lift is moving down at steady speed**
- **The lift is speeding up while going up**
- **The lift is slowing down while going up**
- **The lift is speeding up while going down**
- **The lift is slowing down while going down**

M35

When an object changes in its distance from the centre of the earth how does this effect its

(a) mass
(b) weight
(c) volume?

M36

You are in an aeroplane that is flying at constant speed in a straight line. There is another plane nearby flying in a circle, with an observer on board who is looking at your plane. To this observer, what shape path will you appear to be flying in?

M37

Do air molecules move in parabolic paths between collisions?
Explain the reasons for your answer.

M38

A satellite is orbiting the Earth at constant speed.

- **Is its velocity constant or changing? Explain your answer.**
- **Is work being done on the satellite? Explain your answer.**
- **Is the satellite's energy changing? Explain your answer.**

M39

Galileo and Newton said that things keep moving at constant velocity if no force is applied to them, yet you have to keep pedalling to keep a bicycle moving. Explain this.

M40

Where does the kinetic energy of a car go when it stops?

M41

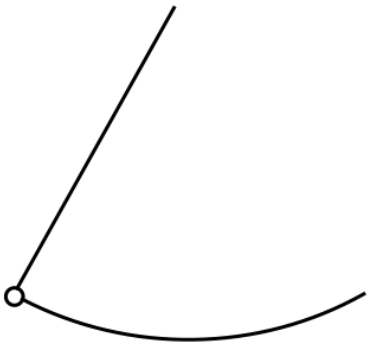
Two children are on a merry-go-round. John is on the inside, Ann on the outside. Say whether the following quantities are greater for John, greater for Ann, or the same for both children:

- **their speeds**
- **their accelerations**
- **the centripetal forces on them**
- **their angular velocities**

M42

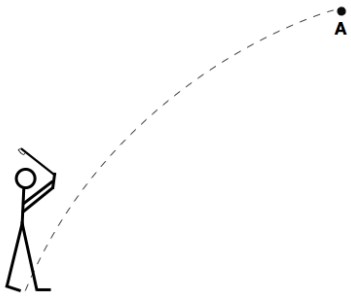
Draw a diagram to illustrate the statement: "We went 20 kilometres, but our displacement was only 5 kilometres."

M43



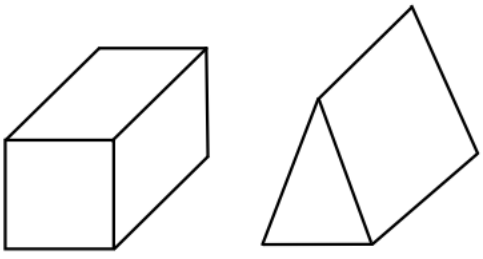
The pendulum has swung as far to the left as it will.
Draw an arrow from the bob to show the direction of its acceleration (if there is no acceleration, put an X on the bob).

M44



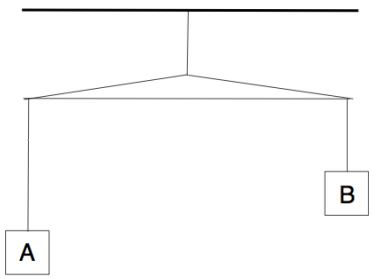
Draw arrows to show the directions of any forces that are acting on the golf ball when it is at A, and label the arrows with the names of the forces.

M45



Which of the blocks would be harder to tip over?
Why?

M46

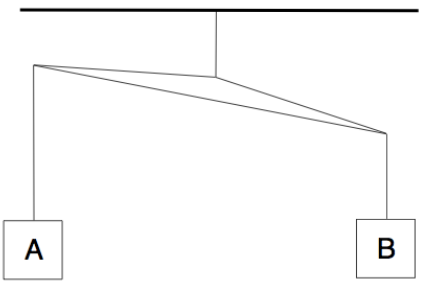


Blocks A and B are stationary, and hang by strings from a triangular beam, which also hangs on a string.

Are blocks A and B the same weight, or is one heavier?

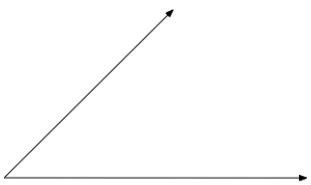
M47

Blocks A and B are stationary, and hang by strings from a triangular beam, which also hangs on a string.



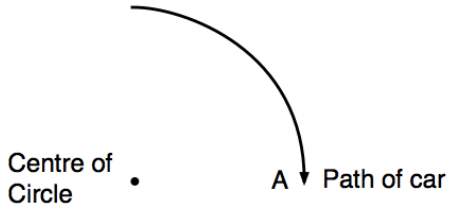
Are blocks A and B the same weight, or is one heavier?

M48



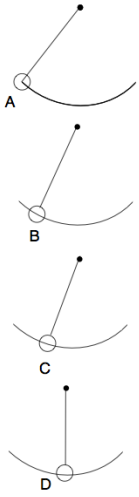
The arrows represent two forces acting on an object.
Draw a third arrow to show a force that would exactly balance the other two.

M49



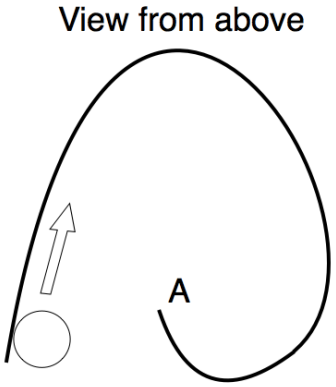
A car follows a circular track and speeds up as it does so.
Draw an arrow to show the direction of its acceleration.

M50



These diagrams show a pendulum at different points in its swing.
Draw an arrow to show the resultant force on the swinging weight when it is
(A) at the top of its swing
(B) on the way down
(C) further on the way down
(D) at the bottom of its swing

M51



A marble is fired along the inside of a horizontal metal track.
Draw the path of the marble after it passes point A at the end of the track.

M52

Two balls are thrown, one (A) straight up, and the other (B) at an angle. They have the same mass and the same initial <u>vertical</u> speed.
Say whether the following quantities are greater for A, greater for B, or the same for both (ignore air resistance).

- **the gravitational forces on them**
- **the maximum heights they reach**
- **their kinetic energies immediately after they have been thrown**
- **the time taken to reach maximum height**
- **the time they are in the air**
- **their speeds at the top of their flights**
- **their accelerations on the way down**

M53

Design a method of comparing masses that would work in a region of zero gravity.

M54

You are floating north in a basket under a drifting balloon, and you hold up a paper streamer. Which way will the streamer point?

M55

Bismuth is used in alloys for making some castings because it expands as it solidifies. Will solid bismuth float or sink in liquid bismuth?

M56

Explain why the unit of acceleration is metre per second per second.

M57

Is it possible to shape material that is denser than water so that it will float?

Is it possible to shape material that is less dense than water so that it will sink?

M58

A metal rod fits snugly in a hole drilled through an iron plate. The rod is taken out of the hole and the plate is heated strongly.
Will the rod still fit through the hole?

M59

Water in a bucket freezes to a solid block of ice. When the temperature rises, the ice starts to melt. The remaining block of ice will start to float

A: as soon as there is enough water to make a layer underneath it and up the sides

B: when half the ice has turned to water

C: when the water around the sides of the block has the same weight as the ice

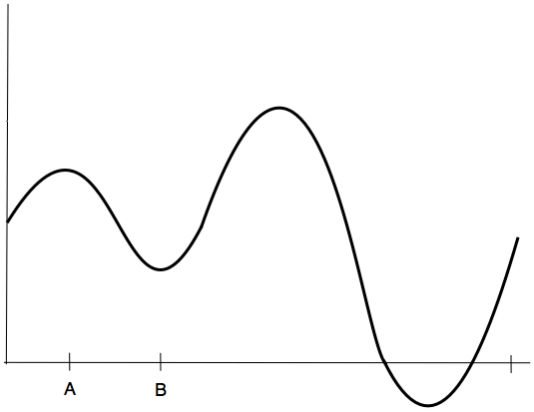
M60

From *Quiller's Run*, a novel by Adam Hall:

"…you are in the movies when a man gets shot and goes flying backwards as if he's been hit by a train and I suppose it looks cute but work it out for yourself in terms of basic physics, force exerts equal force in the opposite direction, so the gunman would go flying backwards too."

Is this correct? Discuss it.

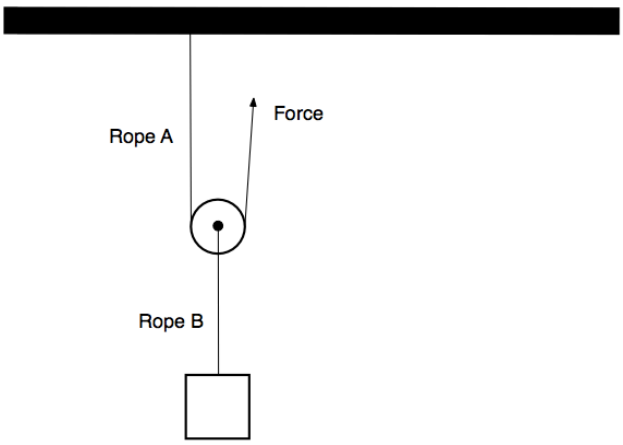
M61



The graph shows the acceleration of an object against time.

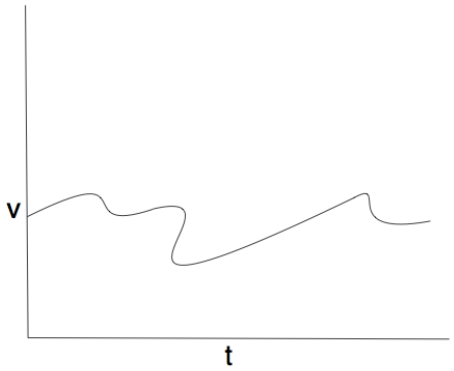
- **How would you find the change in velocity of the object?**
- **Can you tell from the graph the initial speed of the object?**
- **Is there any time when there is no net force on the object?**
- **Is the object speeding up or slowing down between times A and B?**

M62



The two ropes are of equal length.
Which one is more likely to break?
Why?

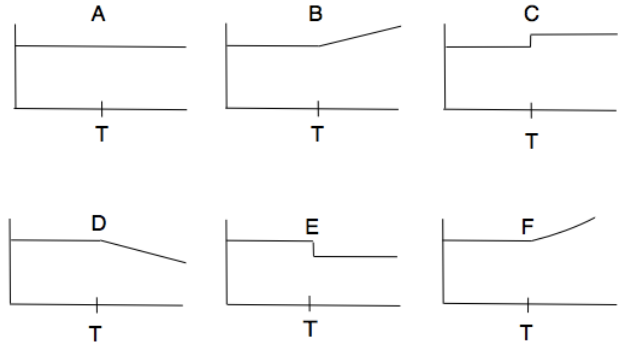
M63



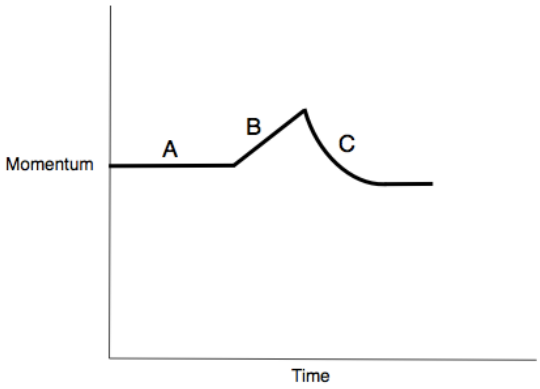
What is wrong with this graph of velocity of an object against time?

M64

A man is gliding at steady speed on smooth ice, when at time T he drops a heavy coat that he was carrying.
Which graph could represent his velocity against time?



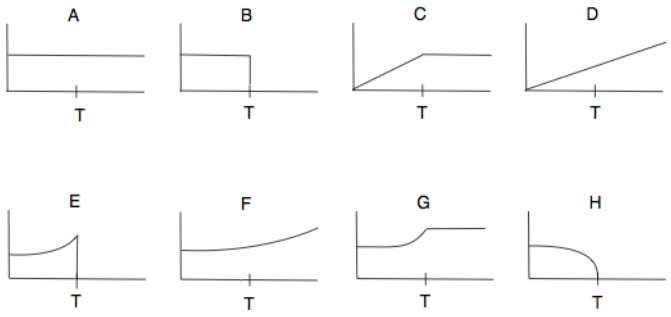
M65



The graph shows the momentum of an object against time.
What can you say about the resultant force on the object in regions A, B, and C?

M66

Fuel in a rocket far out in space burns at a constant rate, so that there is a constant force on it. As the fuel burns the rocket's mass decreases. At time T all the fuel is gone.
Which of these graphs could represent the acceleration of the rocket against time?



M67

Give an example of a coefficient of friction greater than 1.

M68

Explain how you can have an instance of acceleration without velocity, and another of velocity without acceleration.

M69

You have two lumps of different rocks that weigh almost the same. How could you find out which is denser?

M70

Now suppose there are two lumps of different rocks that weigh different amounts. How could you find out which of these is denser?

M71

Would your methods for questions M71 and M72 work if instead of two lumps of rock you had two lumps of plastic that are less dense than water?

M72

What does the potential energy change to when a balloon bursts?

M73

What is one piece of evidence that supports the belief that molecules of a solid, a liquid, or a gas are in continuous motion?

M74

What would you have to know before you could decide whether an elephant puts more pressure on the ground than an ant?

M75

A block of wood floats in water with half of it below and half above the surface. If the wood was put in water in a place where gravity is stronger than on Earth, would it float

A: at the same level
B: deeper in the water
C: less deep in the water

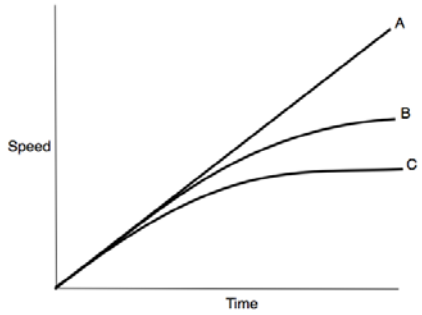
M76

"A black hole is a bottomless pit where potential energy is minus infinity."
Is this so?
What does it mean?

M77

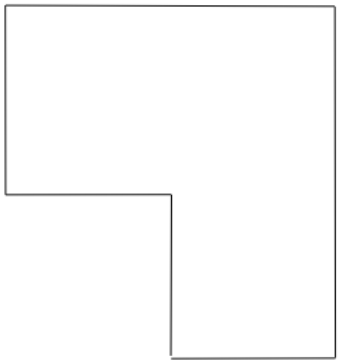
"Objects on the surface of the Earth really have negative potential energy."
Is this so?
In answering, you should say where the zero of potential energy is.

M78



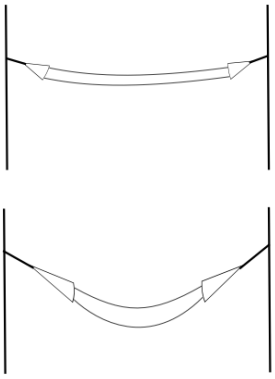
The graphs show speeds of objects falling through different media.
Which graph applies to falling through a vacuum?
Which graph applies to the most viscous medium?

M79



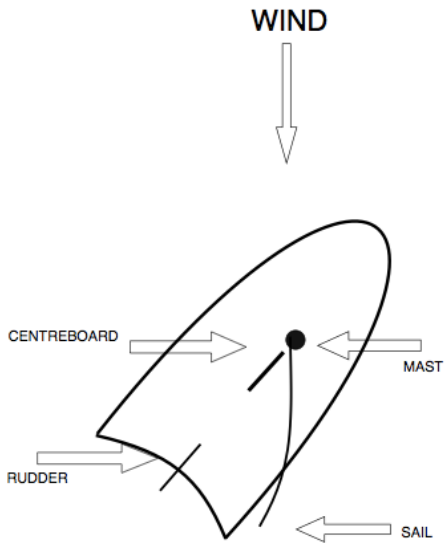
Mark the approximate spot where the centre of gravity would be for the flat sheet shown in the diagram.

M80



Which of these hammocks is more likely to break when someone sits on them?
Explain your answer.

M81



A sailing dinghy is going forward, at an angle to the wind.

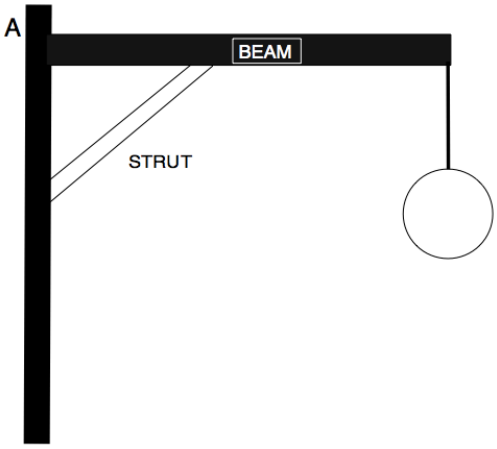
(a) Draw an arrow to show the force on the centreboard, which is under the boat.

(b) Draw an arrow to show the force on the mast generated by the wind on the sail.

M82

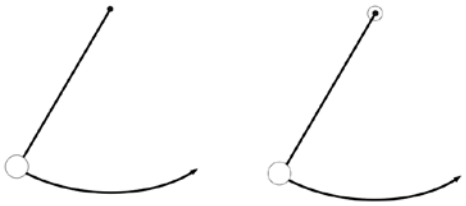
You are sitting on a chair. By holding the seat of the chair and sharply moving your body upwards you can move yourself and the chair forwards even though your feet are off the ground. What is the external force needed for this movement, and where is it applied?

M83



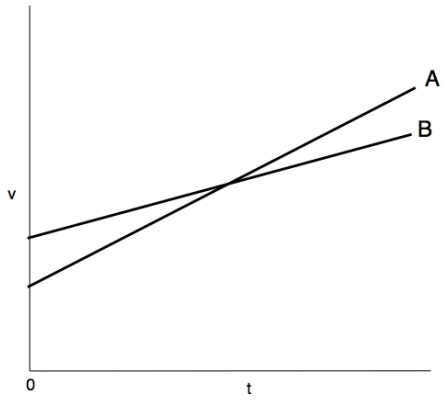
Draw an arrow to show the direction of the force that the joint at A exerts on the beam.

M84



A pendulum is made from a rod with a weight on the end. The period of the pendulum is measured. Now another weight is bolted to the top end of the rod. Will the period now be the same as, more than, or less than it was before?

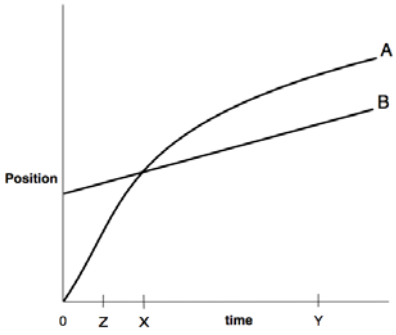
M85



Two cars go past the same point at time 0.

- **Which car is going faster at 0?**
- **Which car is accelerating more?**
- **Mark the time at which they are going at the same speed**
- **Mark the time after 0 at which they have gone the same distance**

M86



- **Which car was going faster at X?**
- **Which car was going faster at Y?**
- **Which car was going faster at Z?**
- **At which point did car A catch up to car B?**

M87

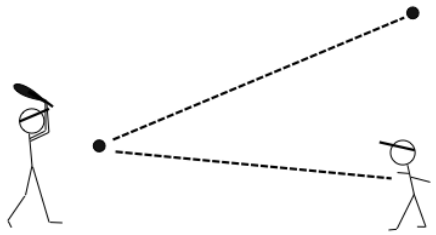
The same size mass sits on a horizontal smooth surface on the Earth and on the Moon. The same horizontal force is applied to it in each location.
Will its acceleration be greater on the Earth, greater on the Moon, or the same in both cases?
Explain your answer.

M88

Why does a table-tennis ball given underspin tend to rise?

M89

A ball is hit with a bat.



The size of the change in momentum of the ball when the bat strikes it is

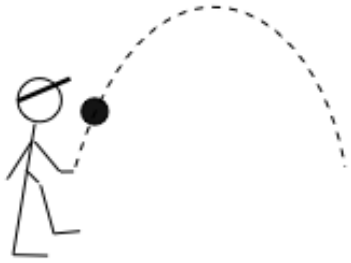
- **equal to the change in momentum of the bat and batter**
- **less than that**
- **more than that**

The change in energy of the ball is

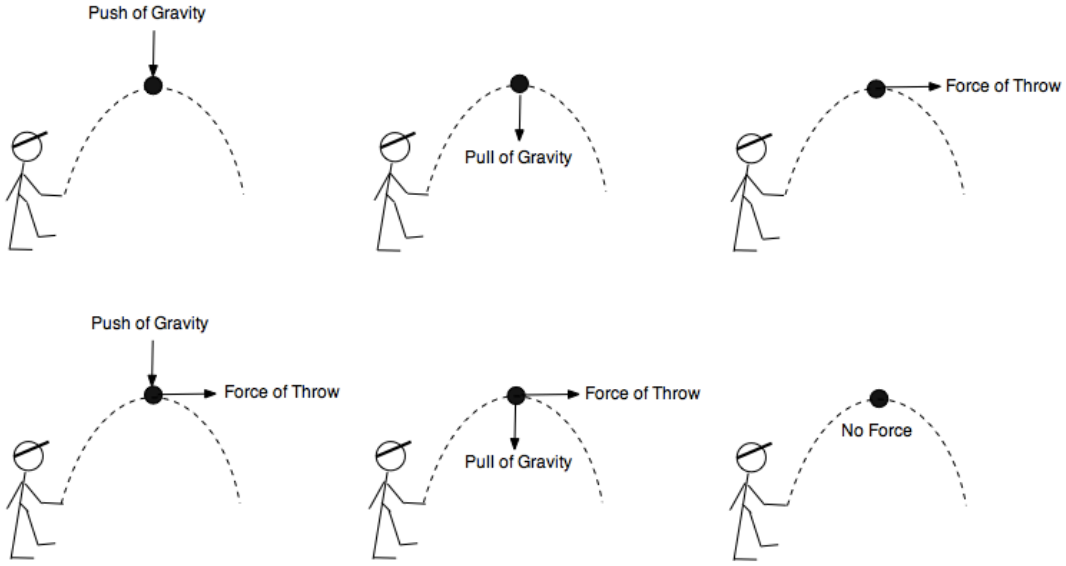
- **equal to the change in energy of the bat and batter**
- **less than that**
- **more than that**

M90

The diagram shows the path of a ball that has been thrown.



Which diagram below best shows all the forces on the ball when it is at its highest point?

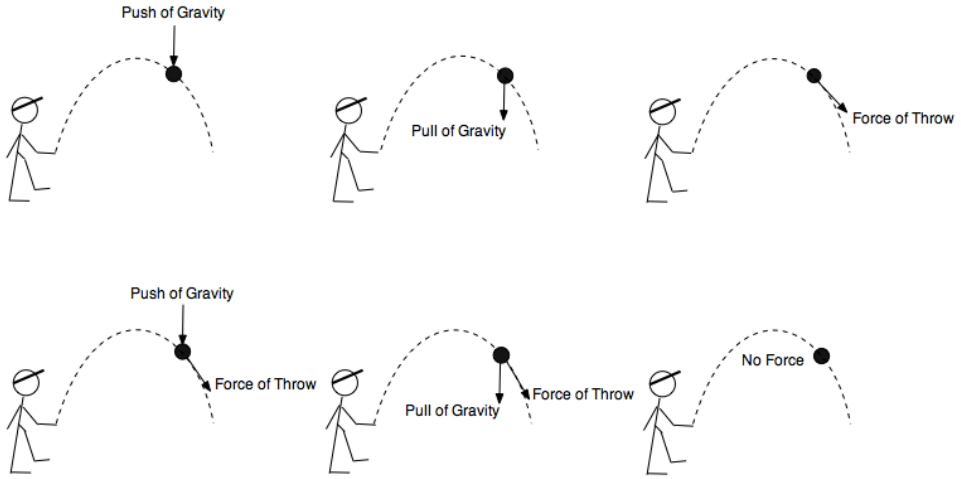


M91

Are there any other forces on the ball that are not shown in the diagrams?

M92

Which of the diagrams below best shows all the forces on the ball when it is on the way down again?

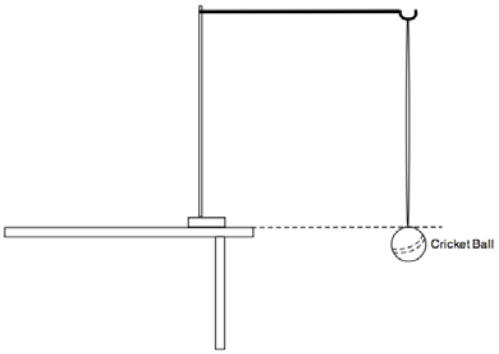


M93

Are there any other forces on the ball that are not shown in the diagrams?

M94

A cricket ball is attached to a rubber band that is hanging from a hook. The ball is level with the top of a table, and is not moving.



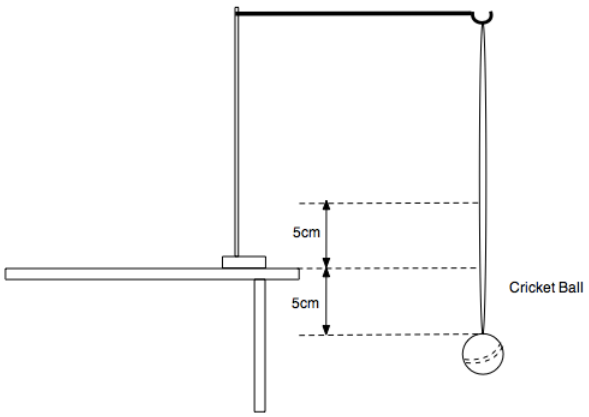
What forces are acting on the ball?

M95

Is the total force on the ball zero?
Explain why.

M96

The ball is pulled down 5cm and let go. It moves up to a point 5cm past the level of the table top.



The total force on the ball as it passes the level of the table top is

A: zero
B: not zero, and in the direction of motion
C: not zero, and in some other direction

M97

At the ball's highest point, the total force on it is

A: zero
B: not zero

M98

The ball is now pulled down more than 5cm below the table top and let go.
The total force on the ball as it passes the level of the table top is now

A: zero
B: not zero, and in the direction of motion
C: not zero, and in some other direction

M99

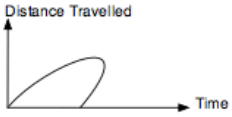
For each of the following graphs answer these two questions:

(a) Could that graph represent an actual event?

(b) If you answer 'yes' to question (a), describe an event that is consistent with the graph.

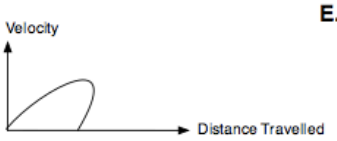
A.

B.

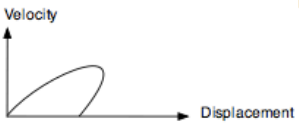


C.

D.

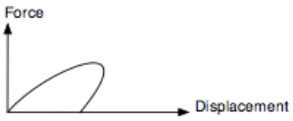


E.



F.

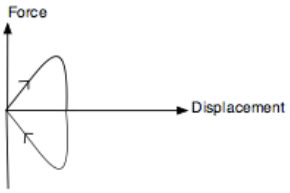
G.



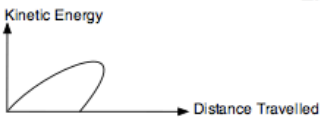
H.

I.

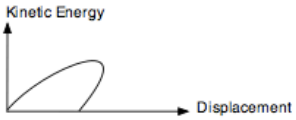
J.



K.



L.



M100

Here is an extract from notes for a program in physical education, which has been broken into three parts labelled A, B, and C.

LINEAR ACCELERATION

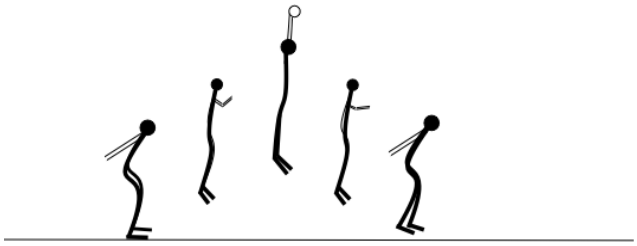
A ***a = (v – u)/t = (final velocity – initial velocity)/time***

……..

B ***If a is negative, then the object is 'decelerating' or 'retarding' or 'slowing down'***

……..

C ***E.g. blocking in volleyball***
Negative acceleration in the air going up;
zero acceleration at height of jump.



Acceleration changes throughout a jump.

……..

Now consider section A.
Comment on the appropriateness of the statement.

M101

Consider section B.
Comment on the appropriateness of this statement, particularly the use of the descriptions 'decelerating', 'retarding', and 'slowing down'.

M102

Consider section C.

- **(a) Comment on the appropriateness of 'acceleration changes throughout a jump'.**
- **(b) What might have led the writer to this opinion about acceleration during a jump?**
- **(c) Rewrite section C so that the physics is correct.**
- **(d) What would happen if, when blocking in volleyball, your acceleration was zero at your highest point?**

M103

You are pushing a supermarket trolley around the supermarket. It has wheels in good condition, and actually goes straight ahead when you want it to.

(a) How should you push the trolley if you want it to go round a corner? Why?

(b) Is it easier or harder to move the trolley round a corner when it is full of groceries? Why?

M104

This description of an example of Newton's third law is taken from a physics textbook. Is the example correct? Give your reasons.

If there is no net force then action and reaction must be equal and opposite. This illustrates Newton's *third law of motion* which states that:

to every action there is an equal and opposite reaction.

The most common reaction force is one which is equal and opposite to the weight-force of an object. Consider an object of mass m at rest on a surface on Figure 2.7. The weight of the object is given by *mg* acting vertically downwards. The equal and opposite reaction force is known as the *normal reaction*, as it is at right-weight angles to the surface.

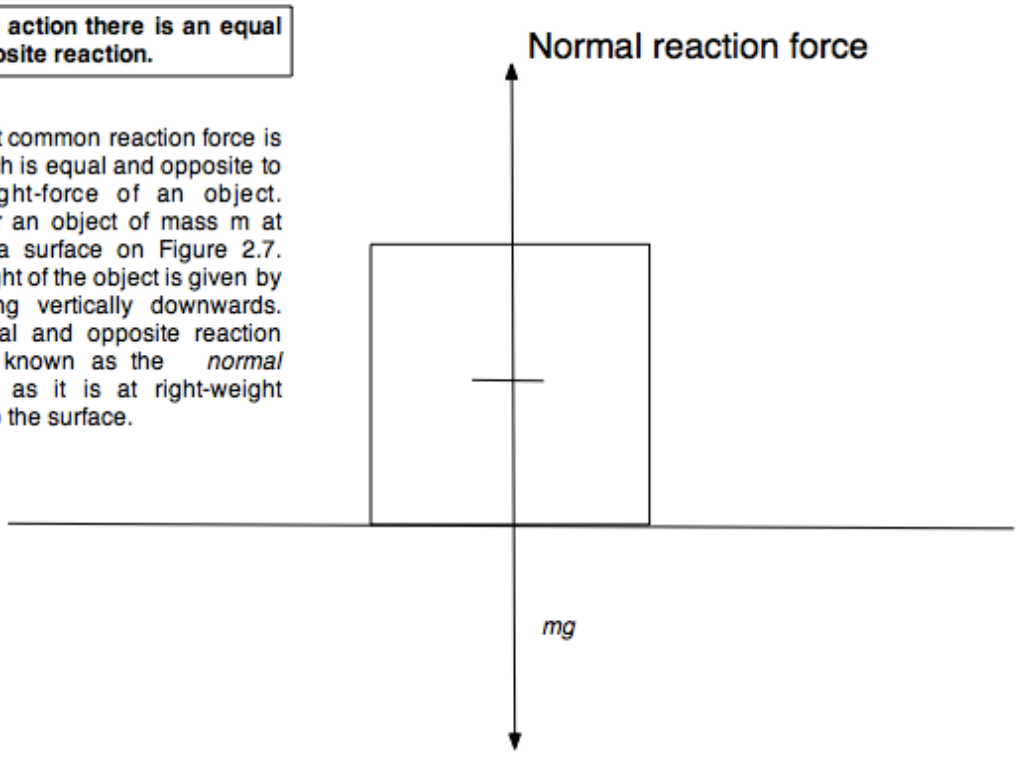
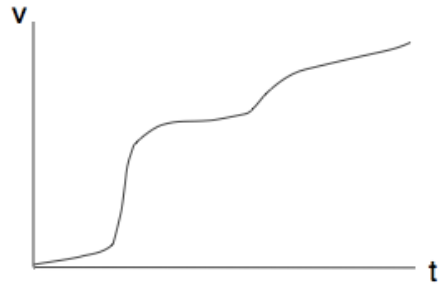
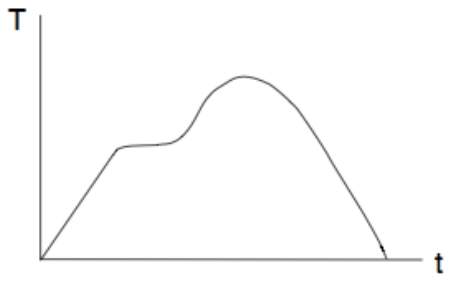


Figure 2.7

M105

Here are velocity-time graphs for two different objects.
Mark on each graph the points for which the instantaneous acceleration of the object is equal to the average acceleration over the time period shown on the graph.



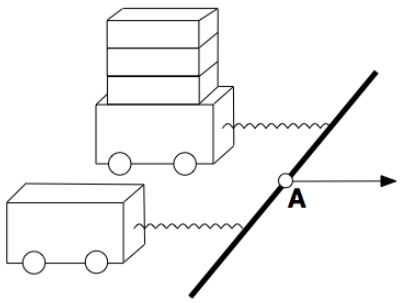


M106

Give an example of an everyday instrument that measures instantaneous speed.

M107

A laboratory trolley loaded with bricks is next to an unloaded trolley. Each has a spring connected to it. The other end of each spring is tied to a rod.

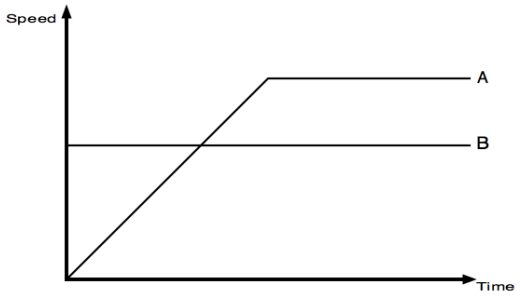


You now hold the rod at A and pull with steady force in the direction of the arrow.

(a) Describe how each trolley will move.
(b) Sketch a speed vs time graph for each trolley.

M108

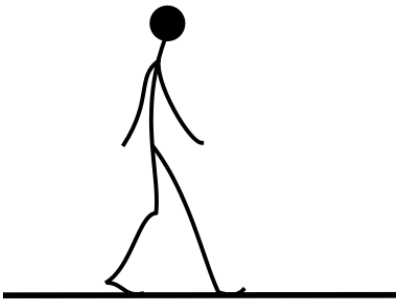
A speeding car passes a stationary police motorcycle. The policeman gives chase. Here are graphs of the two motions.



(a) Which graph represents the motion of the car and which the motorcycle?

(b) Explain how you could use the graphs to find out how far the policeman travels before he catches up to the car.

M109



You are walking across a room, from left to right.

Draw an arrow to show the direction of the force that the floor exerts on you.

M110

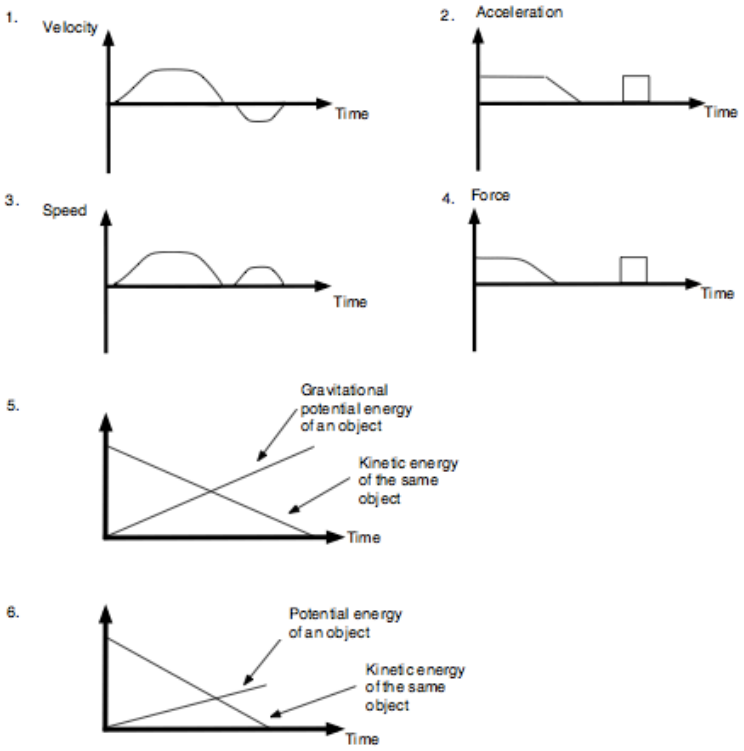
A rope is tied to a hook on a wall. A man pulls on it as hard as he can. The rope is <u>just</u> strong enough not to snap.

The rope is untied.
The man's twin brother, who is as strong as he is, now pulls on the loose end of the rope.

With the two men pulling, will the rope break?

M111

For each of the following graphs, describe an event that would be consistent with <u>all</u> features of the graph.



M112

Write two questions for which an appropriate answer would be 'because the time of the collision is longer, the average force exerted by the colliding objects on each other is less'.

M113

Write two questions for which an appropriate answer would be "Because at that point the gravitational force is the same as the centripetal force required to maintain circular motion'.

M114

A cork is floating in a bucket of water in a lift. The lift starts moving up.

Describe the motion of the cork as seen by someone in the lift.

M115

For each of the following cases of circular motion

(a) draw a force diagram

(b) explain the cause of the centripetal force

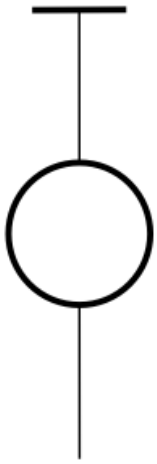
- **a coin on a rotating turntable**
- **a car going round a bend**
- **the Moon going round the Earth**
- **a stream of water inside a bent pipe**
- **a child on a merry-go-round**

M116

How does a spin dryer extract water from wet clothes?

M117

A metal ball is hanging from the roof, suspended by a cotton thread. A second thread is tied to the bottom of the ball.



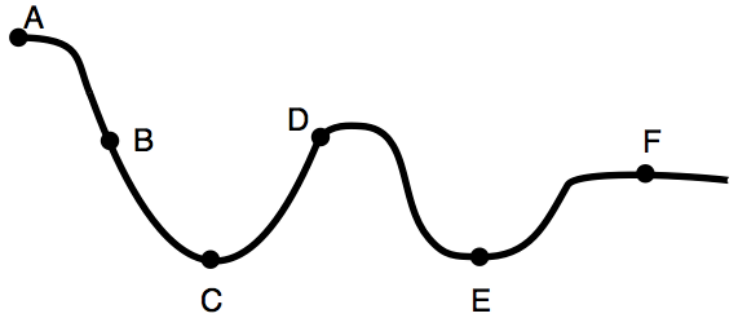
If you grasp the bottom thread and pull sharply, the bottom thread breaks. But if you pull gently, the top thread breaks.

(a) explain this

(b) now explain it again, without using the term 'inertia'.

M118

A physics teacher goes to an amusement park with a spring with a metal weight hanging from it. He gets on the roller coaster holding the spring at the top so that it hangs in front of him.
Here is a view of one part of the roller coaster track.



(a) Draw the spring, showing its length relative to the original length, as it would be at each of points A, B, C, D, E, F.
(b) Sketch a graph showing the length of the spring against distance travelled from A to F.

M119

When you jump from a chair down to the floor, it is wise to bend your knees as you land. Why?

M120

Why do rockets work more efficiently when there is no atmosphere around them?

M121

A volt is a joule per coulomb; that is, a volt is a measure of energy per unit charge.
(a) We could have a similar unit in mechanical energy contexts – a joule per kilogram. Describe a situation where joule per kilogram could be a useful unit.
(b) How do electric cells and batteries give a constant quantity of joules per coulomb?

M122

You push your physics book along a bench. When you take your hand off the book it slides to a stop, so that its momentum changes from some value to zero. What has happened to the momentum of the book?

M123

Why is it harder to close a door if you push near the hinges than if you push near the edge furthest from the hinges?

M124

Because you are a student of physics, you are asked to answer this question by a young relative: "What is friction?"

(a) What will your answer be if the relative is eight years old?

(b) What will your answer be if the relative is fourteen years old?

M125

Some students were discussing what keeps satellites travelling in a circular path around the Earth. One student gave an answer that had five points, which are set out below.

For each point, say whether or not you agree with it, and explain your decision.

- **Point 1: There must be gravity in space because otherwise the satellite would move in a straight line. Instead, it curves and goes in a circle around the Earth.**
- **Point 2: Gravity is always pulling towards the centre of the Earth, which is the same as saying that the gravity is always pulling inwards.**
- **Point 3: Even though gravity is pulling inwards, the satellite does not spiral in to the Earth. Instead it moves in a circle, neither getting closer nor further from the centre of the Earth. Therefore there must be some other force to counteract gravity.**
- **Point 4: This counteracting force is centrifugal force. This is an outward force present with all circular motion. The amount of centrifugal force balances the gravity, and this keeps the satellite from getting either closer to or further away from the Earth.**
- **Point 5: The circular motion causes the centrifugal force. There is no centrifugal force until there is circular motion. Straight-line motions do not create a force, only circular ones do.**

M126

A playful child ties a string to a block of wood, and hangs the wood from the ceiling of a train. The wood hangs like a pendulum.
Describe the pendulum in each of these situations:

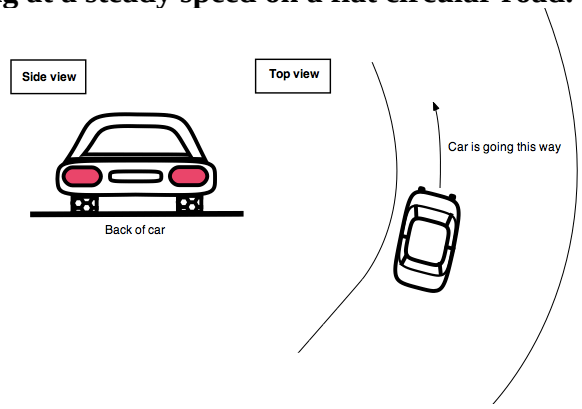
- **(a) The train accelerates away from the station.**
- **(b) The train travels at a steady speed along a straight track.**
- **(c) The train travels at a steady speed around a curve.**
- **(d) The train brakes as it comes to the next station.**

M127

The gravitational field at the north pole is slightly greater than at the equator.
Will a given pendulum have a greater frequency at the pole or at the equator, or won't it differ?

M128

A car is travelling at a steady speed on a flat circular road.



- **(a) What forces are acting on the car?**
- **(b) The total force on the car is**
  - **A: zero**
  - **B: not zero, and in the direction of motion**
  - **C: not zero, and in some other direction**

Another car is travelling on the same road. It is an open car, and you are sitting in the middle of the back seat.

- **(c) What forces are acting on you?**
- **(d) The total force on you is**
  - **A: zero**
  - **B: not zero, and in the direction of motion**
  - **C: not zero, and in some other direction**

M129

The areas below represent two groups of objects:

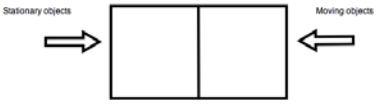
(a) Show on this diagram appropriate areas for

- **objects with zero resultant force acting on them**
- **objects with a resultant force acting on them**

(b) For each of the separate areas that are now shown on the diagram, give an example of an object that is appropriate to that area.

M130

Stationary and moving objects are represented in this diagram:



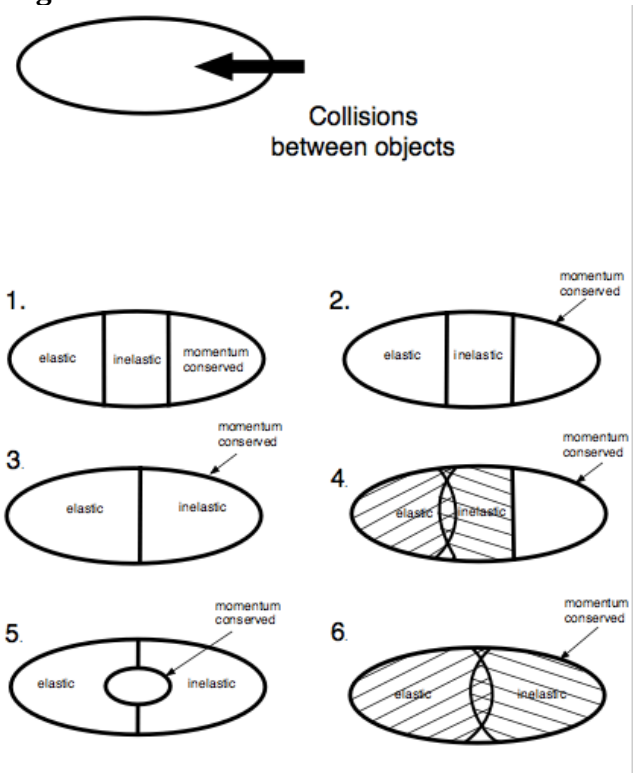
(a) Show on the diagram appropriate areas for

- **objects having work done on them**
- **objects having no work done on them**

(b) Give an example appropriate for each separate area in your diagram.

M131

Imagine a group of students putting in areas for "elastic collisions", "inelastic collisions", and "collisions in which momentum is conserved" into the following diagram:



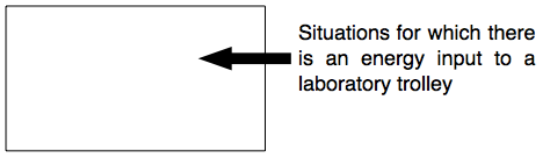
Here are six answers from the students:

(a) **For each answer, describe the relationships between the three ideas that are represented by the diagram.**

(b) **Which of the six is the best representation? Why?**

(c) **For the answer you gave to (b), give an example of a collision appropriate to each area of the diagram.**

M132



(a) Show on this diagram
situations in which the kinetic energy of the trolley is changed
situations in which the gravitational potential energy of the trolley is changed

(b) Now indicate on the diagram the appropriate position for each of the following situations. Also state, with reasons, whether your diagram had to be changed to accommodate the situation:

- **the trolley is accelerated horizontally**
- **the trolley is accelerated up a ramp**
- **the trolley is accelerated down a ramp**
- **the trolley is pushed over the end of the bench and falls to the floor**
- **the trolley is put in an oven and heated until the wood burns**

M133

The following extract is from a radio broadcast to schools in Australia on 27 November 1991:

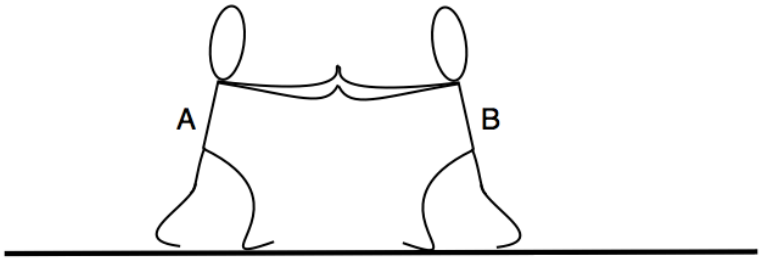
"When a stone falls to earth, not only does the earth exert a force on the stone, the stone exerts a force on the earth. But because the force exerted by the earth is very much greater than the force exerted by the stone, then the stone moves much faster."

(a) Consider the argument in the first sentence. If you think it is correct, say why; if it is incorrect, rewrite it.

(b) Do the same for the second sentence.

M134

Two people, A and B, are standing on ice.

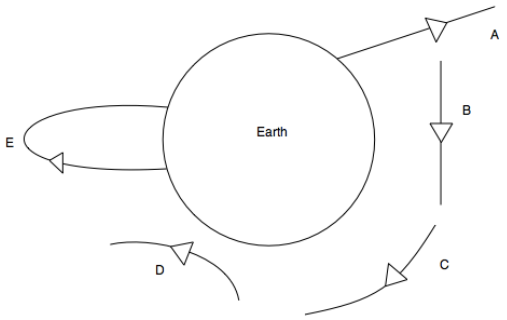


(a) If A pushes B, <u>both</u> people move away from their initial positions. Why?
(b) If you used the term "momentum" in your answer to (a), give another explanation without using this concept.

Suppose A now pushes down on the shoulders of B and rises.
(c) Does B move in the opposite direction (downwards)?
(d) How does conservation of momentum relate to this circumstance?
(e) Person A comes back down to the ice. Does B move upwards in this case?
(f) How does conservation of momentum relate to this circumstance?

M135

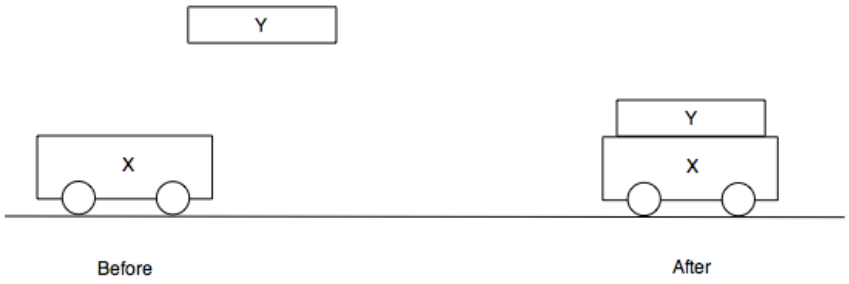
The diagram shows a number of paths along which objects move near the Earth.



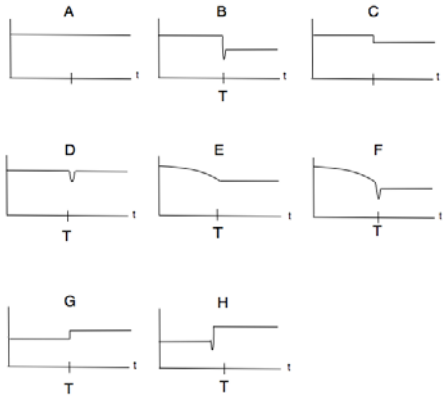
Which one or more of the paths would result in the magnitude of the gravitational force on the object
(a) increasing then decreasing
(b) remaining constant
(c) decreasing
(d) decreasing then increasing
(e) never being zero

M136

In a physics experiment a trolley (X) is rolling at steady speed along a bench with minimal friction. At time T a brick (Y) is dropped a very short distance vertically on to the cart.



Here is a series of graphs, with time on the horizontal axis:



(a) Which graph best represents

- **Velocity of X versus time?**
- **Velocity of the centre of mass of X and Y over time?**
- **Momentum of X versus time?**
- **Momentum of X and Y together versus time?**
- **Kinetic energy of X versus time?**
- **Kinetic energy of X and Y together versus time?**

(b) Write a brief explanation in support of each answer above.

(c) If the brick Y was dropped onto X at an angle forwards, with the horizontal component of its velocity greater than that of X, what effect would this have on

- **the velocity of X**
- **the momentum of X?**

(d) The brick Y is now lifted vertically off the cart, which is still moving.

- **sketch graphs showing before and after the lifting off for the velocity, kinetic energy, and momentum of X.**

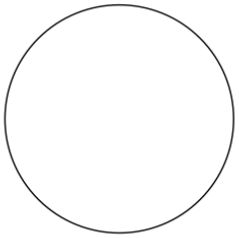
Explain your graph.

M137

"A physics student is travelling in a train. She is bored, and takes a ball out of her bag and throws it up about half a metre."
Use this situation to create two questions that would test understanding of frames of reference and relative motion.

M138

This area represents "all motions with changing velocity".



Show on the diagram appropriate areas for "all motions with changing acceleration" and "all motions with constant (not zero) acceleration",

(a) Now give an example of a motion appropriate to each area you have created.

(b) If there are any areas for which you cannot give an example, reconsider your answer to question (a) and redo the diagram so that these areas do not exist.

(c) Show on the diagram that you now have the appropriate positions for these two cases:

- **a man jumps from a plane and after five seconds opens his parachute**
- **a student pulls a trolley with a rubber band at constant extension**

M139

Can there be more heat in a bucket of cool water than in a cup of hot water? Explain your answer.

M140

A can of hot water is poured into the same volume of cold water. Will the temperature of the mixture be

A: half way between the two temperatures
B: nearer the original hot temperature
C: nearer the original cold temperature

Explain your answer.

M141

Would your answer to the previous question be different if the cold water was poured into the hot water?
Explain your answer.

M142

You have a cup of coffee that is too hot to drink. You blow on the surface of the coffee to cool it.
Describe two ways in which this blowing cools the coffee.

M143

Another person pours hot coffee into a saucer.

(a) **Why will the coffee cool more quickly in the saucer than in the cup, if both are just left standing?**

(b) **If the coffee in the saucer is blown on, will the blowing be more effective in cooling the coffee than it was with the cup? Explain your answer.**

M144

It is midday, and the temperature is high. A motorist pumps up a tyre to a particular pressure. That night the temperature falls. The tyre does not leak.
(a) For each of the following quantities, is the value at night greater than, less than, or the same as the value at midday?

- **the number of molecules of air in the tyre**
- **the average speed of the molecules**
- **the average distance a molecule moves between collisions**
- **the average time between collisions of molecules**

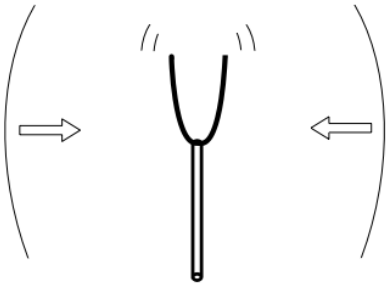
(b) The motorist checks the pressure of the tyre during the night, and finds it is less than it was at midday. He pumps it up to the midday pressure. After the pumping, what has happened to

- **the number of molecules in the tyre**
- **the average speed of the molecules**
- **the average distance a molecule moves between collisions**

(c) Why was the pressure lower when the motorist checked it in the night?

LSW: Light, Sound, and Waves

LSW1



A note is struck on a tuning fork between two reflectors that are moving quickly together.
An observer between the reflectors will hear the pitch of the note
A: increase
B: decrease
C: stay the same
D: alternate up and down

LSW2

A low-flying jet approaches an observer on the ground. It is travelling at a little less than the speed of sound.

How will the note of its engine appear to change to the observer as it passes?

If the plane is slowing down as it approaches the man, how will its note appear to change (a) as it is coming towards him (b) as it is going away from him?

LSW3

The pitch of a note is determined by its frequency. A loudspeaker generates a sound that seems the same when heard in air and under water. Sound travels faster in water than in air.
How does the wavelength of the sound in air compare with its wavelength in water?

LSW4

In the Doppler effect, which of the wave's characteristics appear to change: speed (yes/no), frequency (yes/no), wavelength (yes/no)?

LSW5

Draw the shapes of two waves that

- **(a) have the same note but differ in loudness**
- **(b) have notes of the same pitch but different qualities**
- **(c) have the same quality but different pitch**

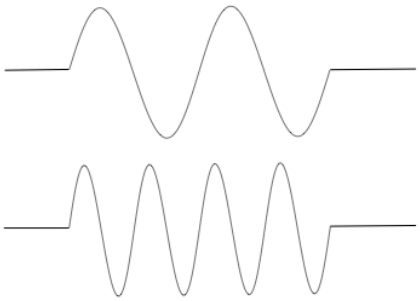
LSW6

Two loudspeakers emit sound waves of the same frequency. An observer moving across the front of the speakers notes regions of greater and lesser sound.
If the speakers are moved closer together, will the observer encounter more or fewer regions?
Explain how there can be regions of little sound.

LSW7

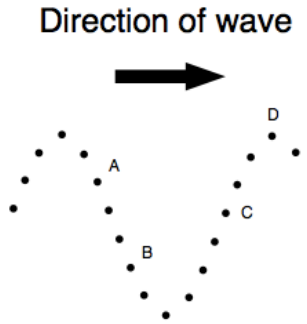
Which sound bends more round a corner – a high-pitched or a low-pitched one?

LSW8



Two pulses interact. Draw the net effect of the two.

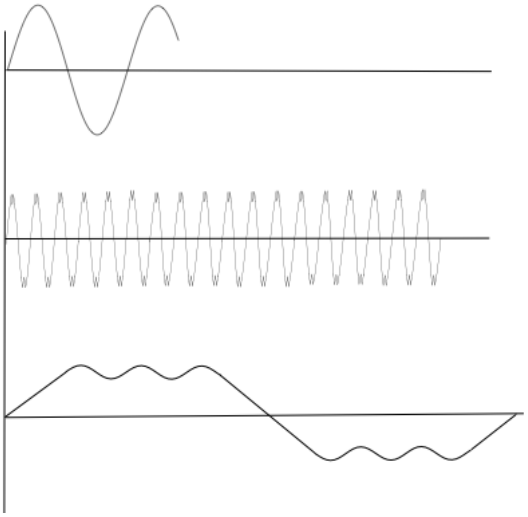
LSW9



A wave passes in the direction shown over a number of particles.

- **draw an arrow to show the direction of the velocity of particle A**
- **draw an arrow to show the direction of acceleration of particle B**
- **which of the particles A, B, C, D has the greatest speed?**
- **which has the greatest acceleration?**

LSW10



The graphs show displacement of air molecules by sound waves.
Which wave has the greatest frequency?
Which has the greatest amplitude?
Which produces the purest note?

LSW11

Draw ray diagrams to show how a diverging lens can be used (if possible) to form a

- **real image**
- **virtual image**
- **magnified image**
- **diminished image**
- **erect image**
- **inverted image**

LSW12

If you can see someone's eyes in a complicated set of mirrors, will he or she be able to look back and see your eyes?

LSW13

Show how you can arrange an object and a converging lens so that the object's image is

(a) real and larger than the object
(b) virtual and larger than the object

Can you have an arrangement where the image is

(a) real and smaller than the object?
(b) virtual and smaller than the object?

LSW14

Is it possible to have a virtual image that is inverted?
If you think so, draw an arrangement that would produce one.

LSW15

Parallel rays of light are brought to a focus by a glass converging lens at a distance L from the lens.
The lens is now immersed in water.
The rays still come to a focus, at a distance D from the lens.

A: D=L
B: D<L
C: D>L
D: more information is needed

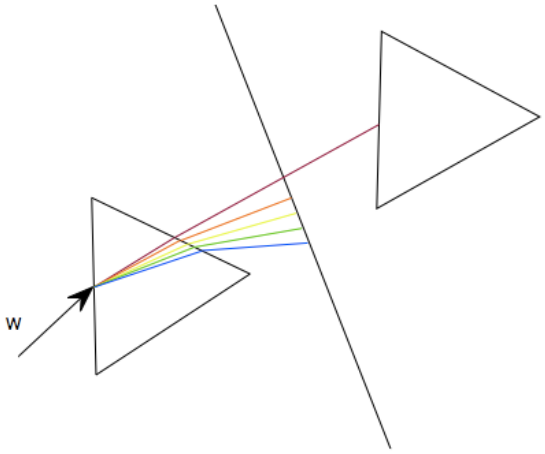
LSW16

What is one property of light that is <u>not</u> consistent with the model that light behaves like a stream of particles?

LSW17

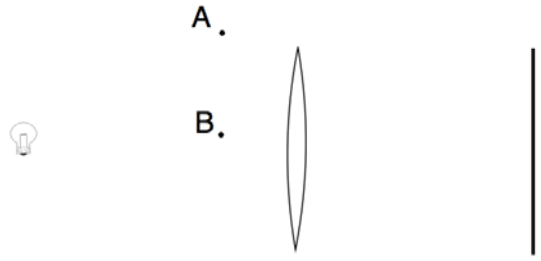
What is diffraction?
Which diffracts more, red light or blue light?

LSW18

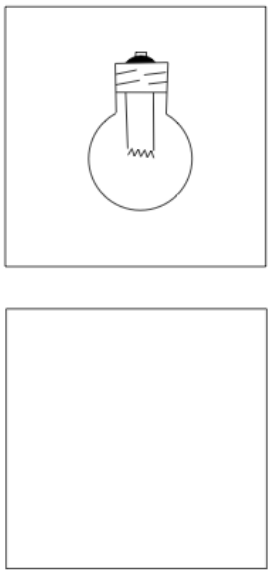


What colour light comes out of the second prism?

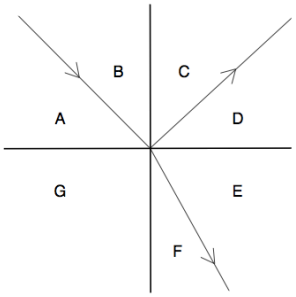
LSW19



The first box below shows the image of the globe that is visible on the screen. In the second box draw what you would see on the screen when a card is placed between A and B, covering the top half of the lens.



LSW20



A ray of light is partly reflected and partly refracted at a surface.

(a) Which of A to G is the angle of incidence?
(b) Which is the angle of reflection?
(c) Which is the angle of refraction?
(d) Which angles A to G are affected if we change material 2?
(e) Which angles A to G are affected if we change material 1?

LSW21

In what ways does light behave as if it were a stream of particles?

In what ways does light behave as if it were a wave?

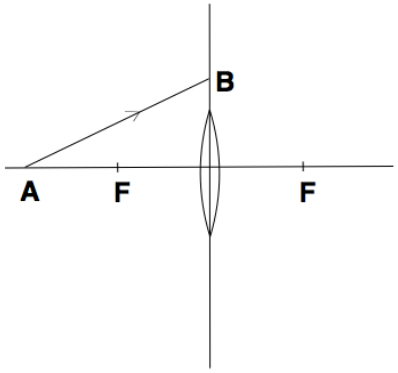
LSW22

If you made a room in which all the walls, floor and ceiling were mirrors, and let a flash of light in, would the light keep bouncing around for ever?
Explain your answer.

LSW23

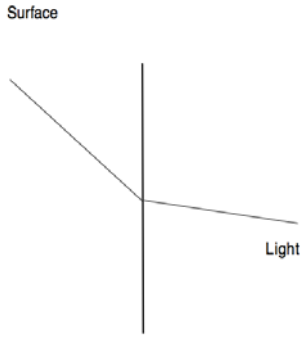
If there is an infinite number of stars, why isn't the sky infinitely bright?

LSW24



Complete the path of the ray A-B after it passes through the lens.

LSW25



The diagram shows a ray of light passing through a surface.

(a) can you tell which way the light is going?

(b) Which medium (left or right) has the greater refractive index?

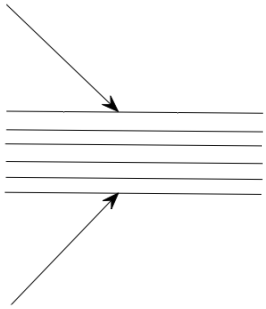
LSW26

A flashlight bulb is at the focus of a parabolic reflector.
How much of the light from the bulb comes out in a parallel beam?

A: all
B: nearly all
C: a bit more than half
D: half
E: a bit less than half
F: a little bit
G: none

Explain your choice.

LSW27



A ray of light strikes a stack of glass plates, which are made of different refractive indexes. They are arranged in order of decreasing refractive index from top to bottom.
Sketch the path of the ray through the stack and beyond.

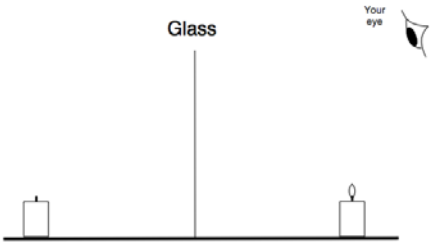
Another ray enters the stack from beneath. Sketch its path.

LSW 28

Write two questions for which an appropriate answer would be "because the surfaces of lenses are curved."

LSW 29

You are looking at a burning candle that is in front of a plane sheet of glass.



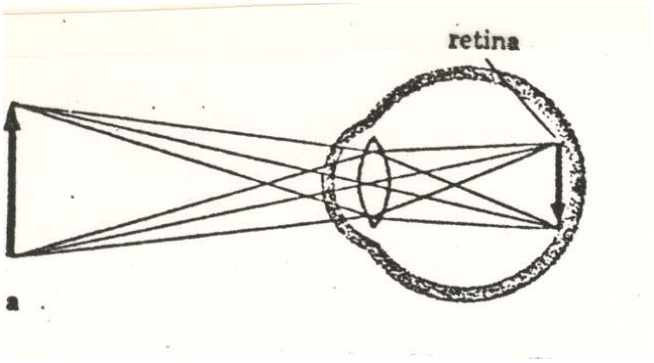
A second candle is the same distance behind the glass as the first is in front. Although the second candle is not burning, it does look as though it is alight.

(a) **Draw two rays of light that could be used to explain why you seem to see the second candle burning. Explain your answer.**

(b) **Draw two rays of light that could be used to explain why you see the first candle burning. Explain your answer.**

LSW30

Here is a diagram from a physics textbook, which shows the optics of the eye.



Is the diagram correct? Give your reasons.

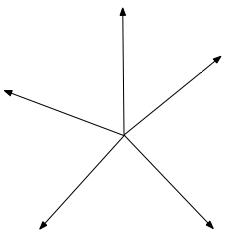
LSW31

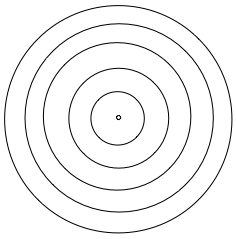
A teacher shines a beam of light onto some plane objects.
Predict what students A, B, and C will see if the object is

- **(a) a clean mirror**
- **(b) a sheet of white paper**
- **(c) a sheet of black paper**
- **(d) a dusty mirror**

LSW32

Here are diagrams showing a point source of light and a point source of water waves:

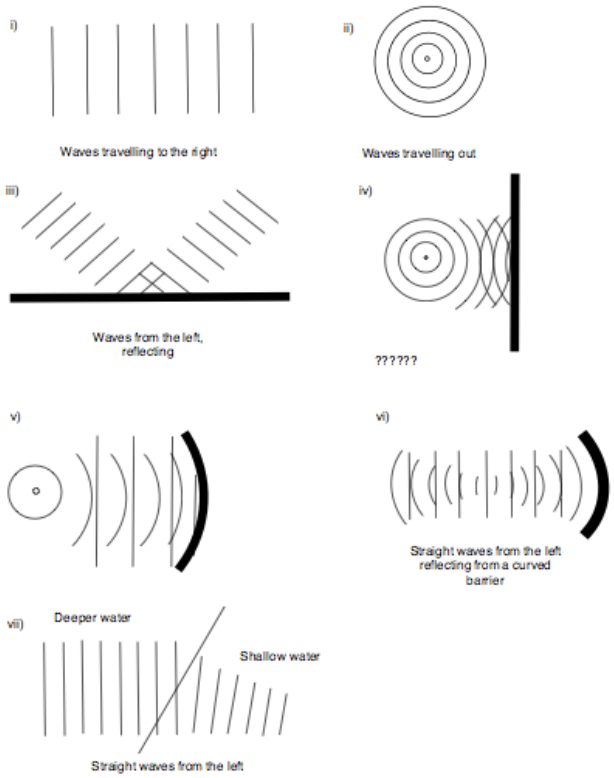

Light


Water waves

- **(a) The straight lines in the light diagram are called "rays". What do the rays represent?**
- **(b) What do the lines on the water waves diagram represent?**

LSW33

For each of the following water wave diagrams, drew two "wave rays":



Why was it necessary to describe the direction of travel of the waves in (i) to (vii) above before you could draw "wave rays"?

LSW34

When swimming underwater you will see more clearly if you wear goggles or a face mask. Why?

LSW35

"Light travels in straight lines". Give two examples in which light has a curved path.

LSW36

A ripple tank enables you to see wave patterns in water. By shining light down through the waves a pattern of shadows and bright areas is formed below the ripple tank.

(a) How are these shadows and bright areas formed?

(b) Which corresponds to wave crests and which to troughs?

LSW37

Your bath can serve as a ripple tank. With water in it and towels hanging over the sides to prevent reflections from the sides, the light in the bathroom ceiling will generate representations of water waves on the floor of the bath.
You generate waves in this bath by releasing drops of water at a constant rate from an eyedropper held well above the surface.

(a) Draw the pattern which will be seen if the dropper:

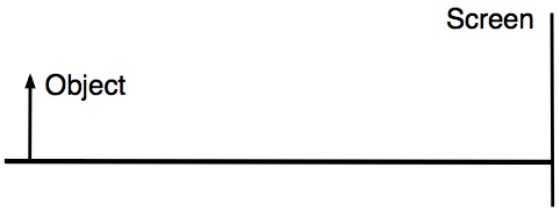
- **is held stationary**
- **moves in a straight line at a speed less than that of the waves it is creating**
- **moves in a straight line at the same speed as the waves**
- **moves in a straight line at a speed greater than the waves**

(b) For each of the above four cases, describe an equivalent example of a phenomenon involving sound waves.

LSW38

To split white light into colours we usually pass a ray through a triangular prism.
Why use a triangular prism instead of a rectangular one?

LSW39



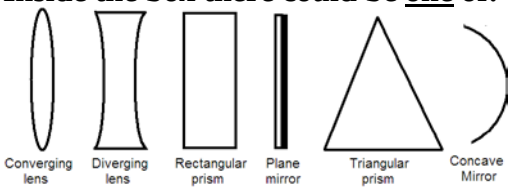
A student finds that, with the object and screen remaining in the same positions, there are two positions at which a converging lens will produce a sharp image of the object on the screen.

(a) Draw ray diagrams to explain the two positions
(b) Which position will produce the larger image?

LSW40

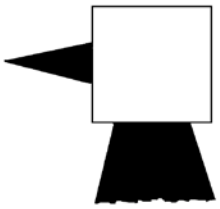
A cone of monochromatic light is shone into a box.

Inside the box there could be <u>one</u> of:

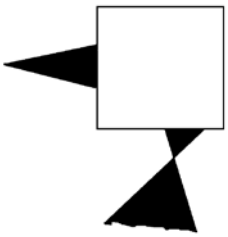


Which one of them could cause each of the following to emerge from the box?

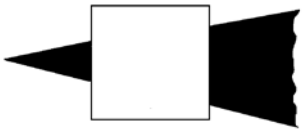
(a)



(b)

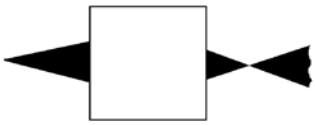


(c)

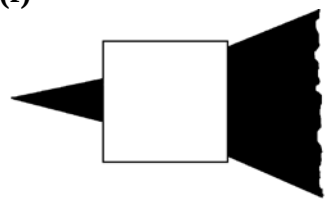


(d)

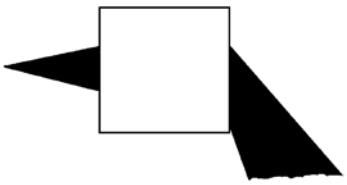
(e)



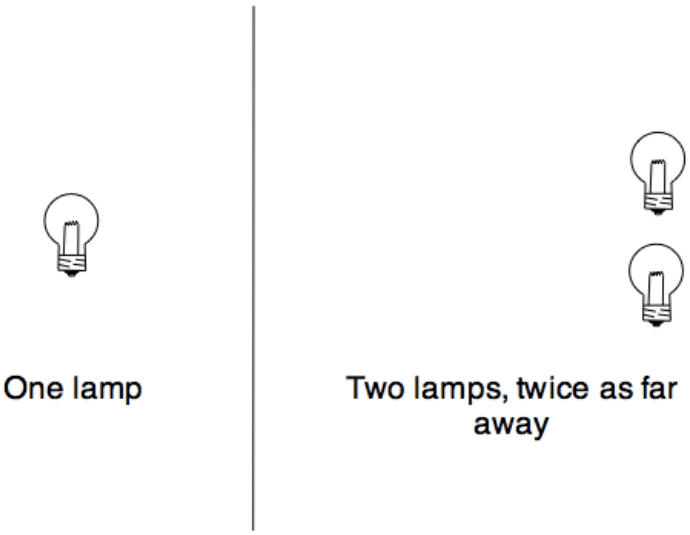
(f)



(g)



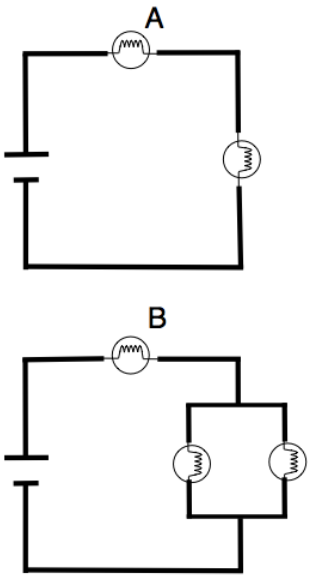
LSW41



Which side of the paper will be more brightly illuminated, or will the sides be equally bright?

EM: Electricity and Magnetism

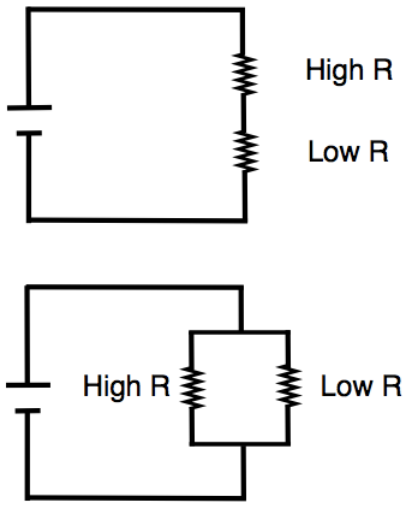
EM1



The batteries are identical. The bulbs are identical.

What can you say about the relative brightness of bulbs A and B?

EM2

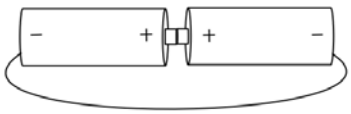


In which circuit will the greater amount of power be used?

In circuit 1, which resistor uses the greater power?

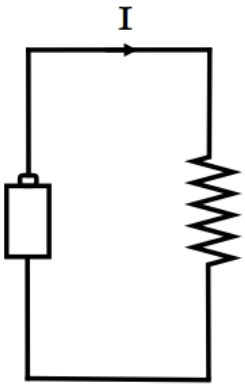
In circuit 2, which resistor uses the greater power?

EM3



Two dry cells are placed with their positive terminals touching.
Will any damage to the cells occur when their negative terminals are connected with a wire?
Explain your answer.

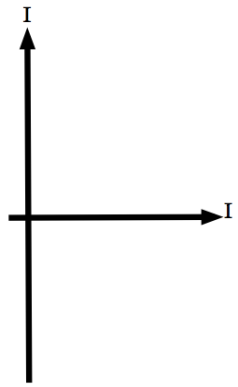
EM4



What is the current in the battery?
A: I
B: 2I
C: 0
D: a bit less than I
E: no-one can tell

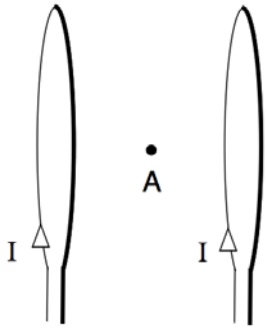
What is the current at point A, the mid-point of the resistance?
A: I
B: ½I
C: 0
D: a bit less than I
E: no-one can tell

EM5



Two wires at right angles carry the same current.
Draw a line through the points where the magnetic fields of the wires cancel.

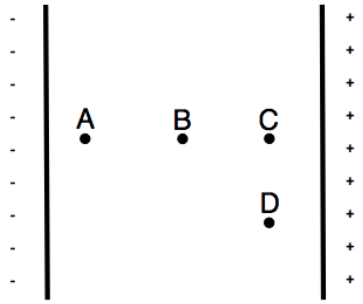
EM6



The magnetic field at point A between the coils will be

A: zero
B: to the right
C: to the left
D: up the page
E: down the page
F: out of the page
G: into the page

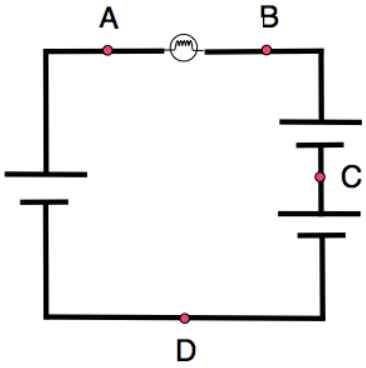
EM7



Points A, B, C, and D are between two large metal discs that carry equal but opposite electric charges.
At which point would there be the greatest force on a small positive charge?

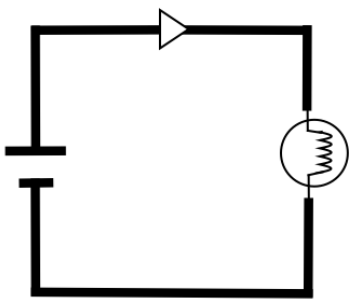
- **A, B, C, D, or same everywhere.**

EM8



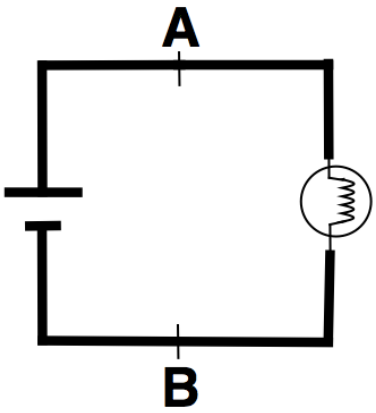
The globe normally shines when connected to one battery.
Will it shine now?
What can you say about the relative sizes of the currents at A, B, C, D?

EM9



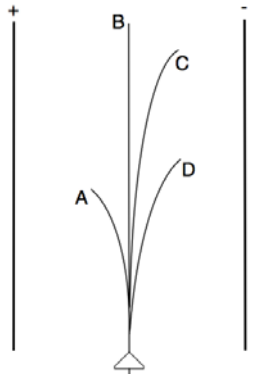
The arrow shows the direction of the current in the top wire.
Place an arrow on the bottom wire to show the direction of the current in it.

EM10



Is the current at A the same as the current at B, or greater or smaller?

EM11



Particles are passing between a pair of plates that are electrically charged.
What are the signs of the charges on particles A, B, C, D (positive, negative, or neutral)?

Particles C and D have the same charge and mass.
Which has more energy?

EM12

Two insulated metal spheres are both given charge +Q. One sphere is larger than the other.

(a) the potential at the surface of the larger sphere is

A: the same as
B: greater than
C: less than

the potential at the surface of the smaller sphere.

(b) the electric field just above the surface of the large sphere is

A: the same as
B: greater than
C: less than

the electric field just above the surface of the smaller sphere.

(c) the potential at a distance R (greater than the radius) from the centre of the larger sphere is

A: the same as
B: greater than
C: less than

the potential at a distance R from the centre of the smaller sphere.

(d) The spheres are touched together then separated.
The charge on the larger sphere will now be

A: Q
B: more than Q
C: less than Q

EM13

Transformers are made of two coils of wire wrapped round opposite sides of a hollow square made of iron. When alternating current flows in one coil (the primary) an e.m.f. is generated in the other coil (the secondary).

(a) what are transformers used for?
(b) what effect does it have if there are more turns of wire in the primary coil than in the secondary?
(c) If a circuit is connected to the secondary coil so that a current flows in it, what effect does this have on the primary circuit?
(d) why do transformers get hot?
(e) the iron core is often made of flat sheets separated by thin sheets of insulator. What is the advantage of this over a single solid block?
(f) why not make transformers by wrapping both coils around the same straight bar?
(g) why don't transformers work with direct current?
(h) is the frequency of the e.m.f. in the secondary the same as the frequency of the primary current?
(i) why must the wires in the coils be insulated?

EM14

Two metal spheres of the same size stand on insulators. One is charged positively, the other is uncharged. Now they are touched together.
The charge on the first sphere will now be

A: the same as it was before
B: the same size as before, but negative
C: half what it was before
D: zero

EM15

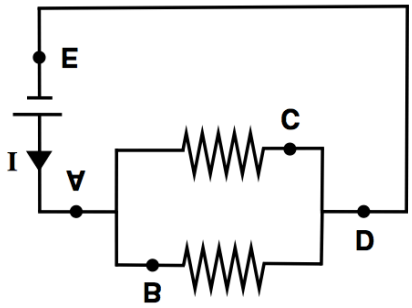
Is the magnetic field at a point near an alternating current ever zero?

EM16

You have eight identical resistances. Three are joined in series.

Draw a diagram of how to connect the other five so that current could flow through them and so that their total resistance is the same as that of the three in series.

EM17



The two resistances are identical. The current at A is I.

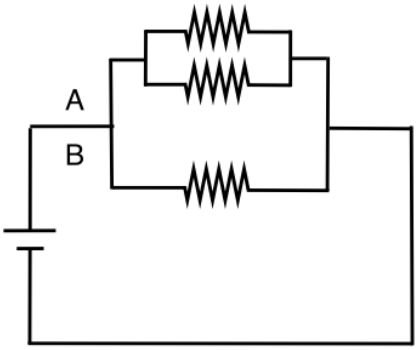
(a) the current at B is
A: I
B: less than I
C: you can't tell whether it is I or less than I

(a) the current at C is
A: equal to that at B
B: less than that at B
C: can't tell

(b) the current at D is
A: I
B: less than I
C: can't tell

(c) the current at E is
A: equal to that at D
B: less than that at D
C: can't tell

EM18



All the resistances have the same value.
In which path, A or B, is the current larger? Or is it the same in both?

EM19

What shape is the path of a charged particle through a uniform magnetic field? Why is it that shape?

EM20

What shape is the path of a charged particle through a uniform electric field? Why is it that shape?

EM21

When calculating the paths of small charged particles through electric and magnetic fields, scientists usually ignore the effect of gravity. Explain why they do so.

EM22

What determines the electrical capacity of an object?

EM23

If you have a big resistance and a small one in series, which one consumes more power?

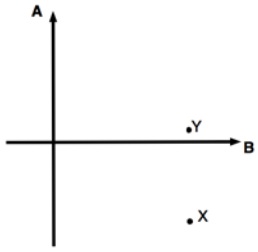
EM24

If you have a big resistance and a small one in parallel, which one consumes more power?

EM25

Which uses more power: two resistances in series or the same two in parallel?

EM26



Two insulated wires carrying current cross at right angles.

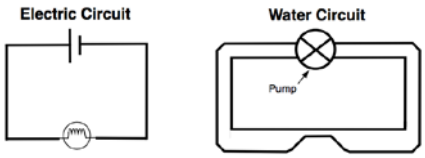
(a) in which direction is the magnetic force that A puts on B?

(b) in which direction is the magnetic field at X?

(c) in which direction is the magnetic field at Y?

EM27

Many physics textbooks argue that simple electric circuits are like water pumped around a pipe:

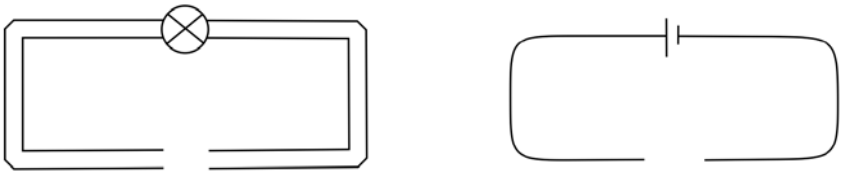


These questions explore when the analogy is helpful and when it is not.

(a) In the water analogy,

- **What corresponds to the electric cell?**
- **Why does it correspond?**

(b) <u>If</u> the electric circuit behaved the <u>same</u> as the water analogy, what would happen in this circuit?



(c) In a water circuit, what causes the friction that means a pump is needed to keep the water flowing?

(d) What causes the resistance in the wires of an electric circuit? Does the water analogy give an appropriate analogy of the cause of the resistance in an electric circuit?

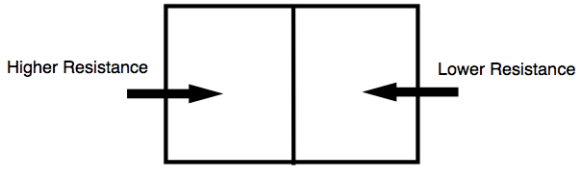
(e) In what other ways is a water circuit NOT like an electric circuit?

(f) In what ways is an electric circuit like a water circuit?

(g) Do these questions suggest that the water circuit analogy is or is not a useful way for thinking about electric circuits?

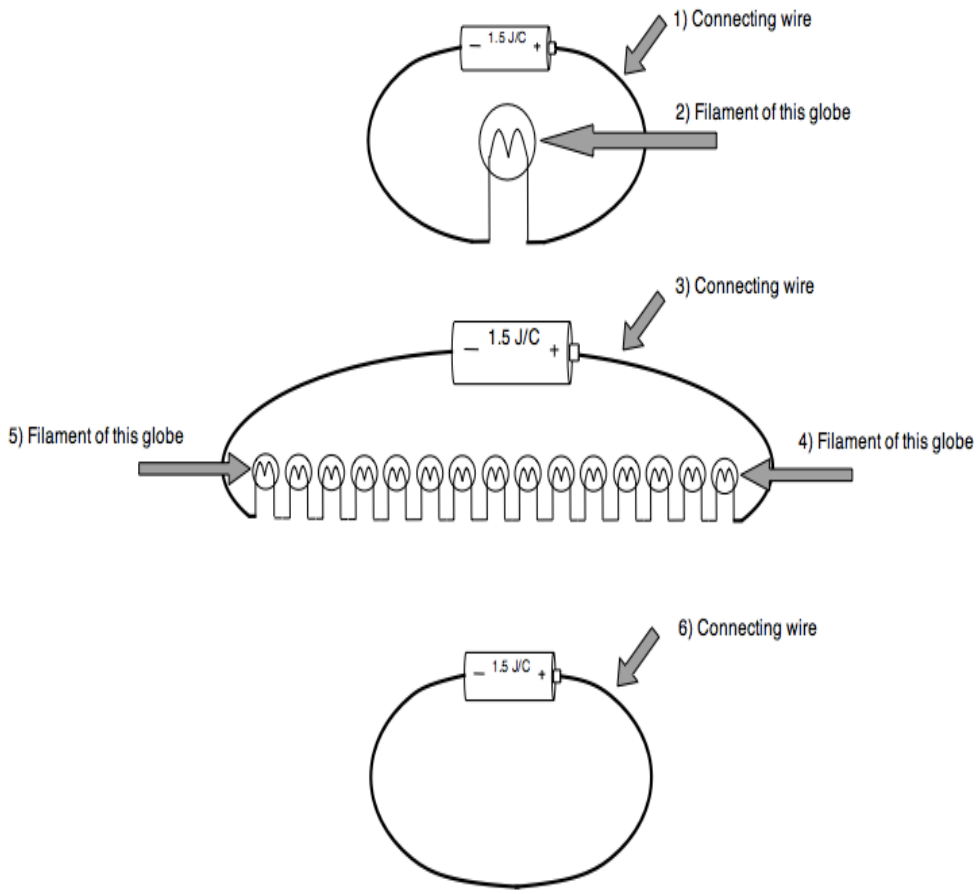
EM28

Consider situations where a conductor might be connected to a torch battery. The conductor can be classed either of "higher resistance" or of "lower resistance".



(a) **On the above diagram show "situations in which <u>a lot</u> of electrical energy is converted to light and/or heat" and "situations in which only <u>a little</u> electrical energy is converted to light and/or heat".**

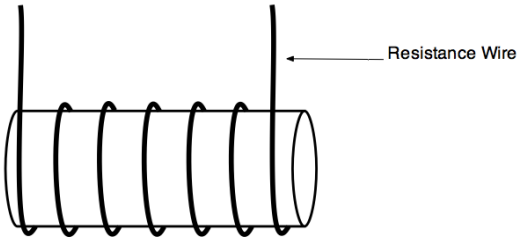
(b) **Now mark on the diagram points to represent each of these six cases:**



(c) **Now make any changes that you think would be appropriate to your diagram.**

EM29

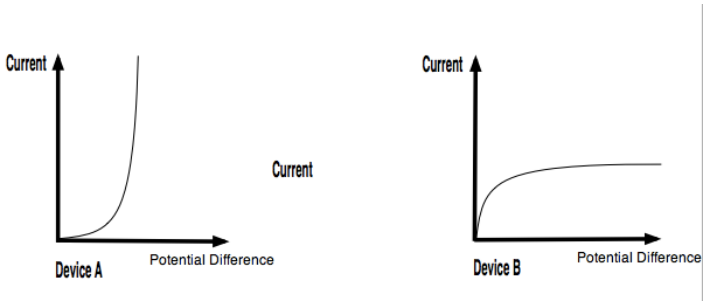
Some electric jugs used for heating water have a heating element that is a wire wound round an insulating core.



If the resistance wire breaks, the jug will not heat up. It is possible to fix the element temporarily by twisting the broken ends of wire together (making sure that you have disconnected the jug first!). The jug then usually heats water more slowly than before. Why?

EM30

Here are curves for two electrical devices showing the variation in current as the potential difference across the device is varied.



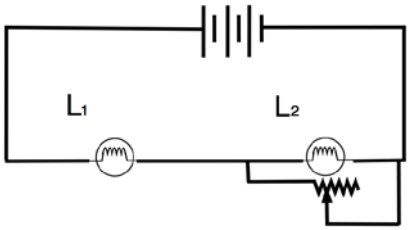
(a) Describe in words how current varies with potential difference for each device.

(b) Describe in words how resistance varies with potential difference for each device.

(c) If the devices were connected in series, describe how the current through the combination would vary with potential difference.

(d) If the devices were connected in parallel, describe how the total current through the combination would vary with potential difference.

EM31

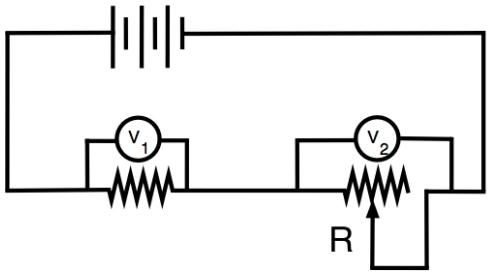


L1 and L2 are lamps. If the variable resistance is increased,

(a) does the brightness of L2 increase, decrease, or stay the same?

(b) does the brightness of L1 increase, decrease, or stay the same?

EM32



The variable resistance R is <u>increased</u>.

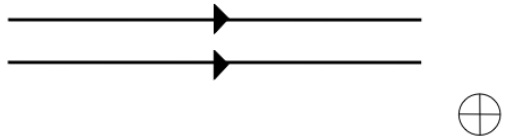
(a) Will the reading on voltmeter V2 increase, decrease, or stay the same? Why?

(b) Will the reading on voltmeter V1 increase, decrease, or stay the same? Why?

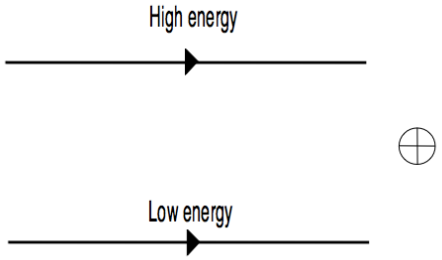
N: Nuclear

N1

Two alpha particles with the same energy approach a heavy nucleus.
Draw the continuations of their paths.

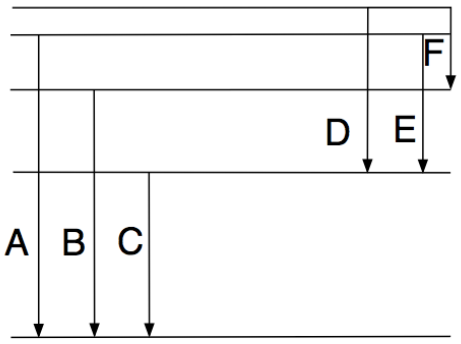


N2



A proton with high energy and one with low energy approach a heavy nucleus.
Draw the continuations of their paths.

N3



The figure shows energy levels of an atom. The arrows show transitions of states of electrons.

Which transition is the one that produces a spectral line of shortest wavelength?

N4

Why does a proton leave a more visible track in a cloud chamber than a neutron with the same energy?

N5

What evidence is there for the existence of discrete energy levels for electrons in atoms?

N6

Why are neutrinos so hard to detect?

N7

Emission of which of the following results in an atom changing to

(a) an atom of a different element

(b) a different isotope of the same element

A: alpha particle
B: beta particle
C: gamma ray
D: neutron

N8

Draw a Venn diagram to show the relation between charged particles, baryons, and leptons.

Mark where mesons fit in your diagram.

Mark where neutrinos fit in your diagram.

G: General

G1

Your young relatives ask you about physics. Give two brief explanations for each of the following questions, one for an eight year old and one for a fourteen year old.

- **What is a force?**
- **How does an electric light globe work?**
- **Why does my aunt have to wear glasses?**
- **How can you make electricity?**
- **Why do batteries go flat?**
- **Why do batteries go flat when they aren't being used?**
- **How does a rocket work?**
- **Are astronauts really weightless?**
- **Why doesn't a bicycle keep going forever when you stop pedalling?**
- **Why do I have to rub my comb to get it to pick up little bits of paper?**
- **Why are there rainbows?**
- **How do mirrors work?**
- **Why does the water coming from a hose hurt you when the tap is turned on all the way?**
- **Why can you dive into water easily but it hurts a lot if you fall flat on the surface?**
- **Why does a table tennis ball swerve so easily?**
- **What is something not made of atoms?**
- **Why does my blue shirt look blue?**
- **Why can birds sit on electricity wires?**

G2

If you saw a half moon rising, what time would it be?

G3

Here is a letter published in the American Journal of Physics (volume 51, no. 8, August 1983, page 684).

LETTER TO THE EDITOR

In response to the call for "new units," I find it unappealing to continue attaching personal names to physical quantities. After all, how much momentum did Descartes or Huygens actually have? I propose rather that we rename all units in the evocative manner currently in use among the particle people, and list some suggestions below. I prefer the suggestive approach to the honor-the-famous-physicist approach for three reasons: (1) If units suggest their physical quantity, students with at least some sort of foggy idea of what a question is all about might do quite well in an essay type of response; (2) I can not remember personal names; and (3) I am not a famous physicist.

Suggested revisions for SI units:

Physical quantity	Present name of unit	Proposed name of unit
Distance, displacement	1 m	1 far
Velocity, speed	1 m	1 far/s [a] = 1 jog
Acceleration (linear)	1 m/s^2	1 far/s^2 = 1 pant
Mass	1 kg	1 lump
Force	1 N	1 shove = 1 lump far/s^2
Work, energy	1 J	1 grunt = 1 shove far
Linear momentum, impulse	1 kg m/s	1 bump = 1 lump far/s
Angular momentum, impulse	1 kg m^2/s	1grind = 1 bump far
Torque, moment of force	1 N m	1 twist = 1 shove far
Moment of inertia	1 kg m^2	1 flab = 1 lump far^2
Pressure	1 pascal	1 gasp = 1 shove/far^2
Power	1 W	1 varoom = 1 grunt/s
Intensity level	1 dB	1 yell = 10 log I/I_0 where I is in varooms/far^2

[a] I contemplated suggesting a new name for the time unit "second," such as one "fidget" or one "yawn," but decided that I might not then be taken seriously.

If the scientific community should adopt these suggestions, I will be most happy to work out a similarly useful designation for physical variables in other branches of the discipline. I am sure there will be lots of help.

W. H. Snedegar
Physics Department
Clarion State College
Clarion, PA 16214

Invent similar units for quantities in electricity:
Charge, current, potential difference, resistance, etc.

G4

In a system where the unit of distance is the far, of mass the podge, of time the mo, and of electric charge the zap, what would be the unit of

- **Velocity**
- **Acceleration**
- **Area**
- **Force**
- **Density**
- **Pressure**
- **Current**
- **Energy**
- **Power**
- **Potential difference**
- **Electric field intensity**
- **Momentum**
- **Impulse**
- **Magnetic flux density**