VANCOUVER ISLAND
U N I V E R S I T Y

Mechanical/Abstract/Spatial Reasoning Review

As part of your assessment, you will have 30 multiple-choice questions on Mechanical Abstract and Spatial Reasoning. You may already be skilled in this area and may not need extra support.

If you do need practice, there are three main sources of help with these types of Reasoning:

1. Study the material on this review and try the practice material.

2. We have 3 copies of *Mechanical aptitude and spatial relations tests / Wiesen, Joel P. (Joel Peter)[aka Barron's mechanical aptitude and spatial relations tests] Hauppauge, N.Y. : Barron's, c2009* in the VIU Nanaimo library.

   These are available for 3-day loans with a valid VIU student card, or with a free temporary community borrower's card, issued if you present proof of registration and picture ID.

   This book can also be requested on the Cowichan and Powell River campuses.

2 Google *Mechanica/Spatial/Abstract Reasoning Examples* and you will find several websites with good support in this area. As many of the examples shown are 'industry-specific', make sure that you are working on examples that are appropriate to the field of work that you wish to enter.

Mechanical Reasoning:

Terms to Know
- Load: what is being moved
- Effort : the force required to move the load
- Distance: how far the load is moved
- Work: the product of Effort (force) x Distance.
- Note: Work is constant; it is the effort required that changes, not the work.
- Resistance: the weight of the load

Mechanical advantage makes the job easier, but there is a price to pay. This "price" is about the *relationship* between the "load" being moved, the "distance" it has to be moved along, and the "effort" that is needed to move it.:

When a small effort moves a large load, the effort has to move farther than the load.

When reviewing the following information on simple and compound machines, think about the relationship between load, distance, and effort.

**Simple Machines**

1. **Lever**
   - A lever makes work easier by using force to move a load around a pivot.
   - A straight rod, a blade, or a board pivots on a point known as a fulcrum.
   - Pushing down on one end of a lever results in the upward motion of the opposite end.
   - The fulcrum can be moved depending on the weight of the object to be lifted or the force you wish to exert.
   - There are three "orders" of levers:

Figure 1 - Levers:

Order 1   Order 2   Order 3
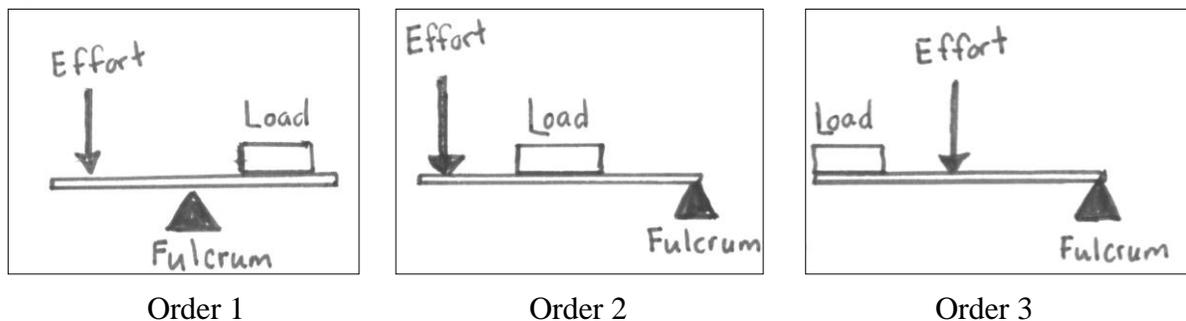
First Order Levers
   - Look at the first picture in the diagram on the page one.
   - The pivot (fulcrum) is between the load and the effort.
   - In some cases, like a see-saw, the fulcrum is in the middle.
   - In other cases it is off-centre, like in pliers. In these cases, the load is larger than the effort, but it is moved across a shorter distance.
   - Some tools have more than one lever, such as pliers.
   - Examples of first order levers: see-saw, scissors, pliers, pry bar.
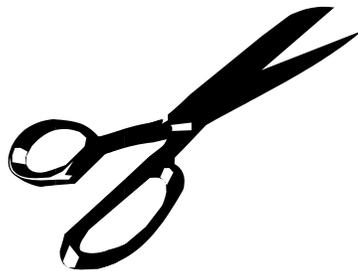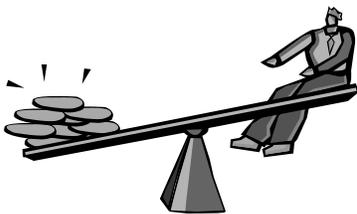
Second Order Levers
- Look at the second picture in the diagram on the page one.
- The fulcrum is at one end, the effort at the other end, and the load is in between.
- See diagrams below.
- Examples of second order levers: stapler, bottle opener, wheelbarrow, nutcracker, nail clippers.
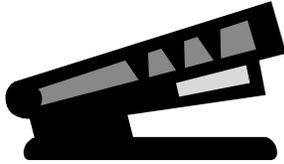
Third Order Levers
- Look at the third picture in the diagram on the page one.
- The fulcrum is at one end, the load at the other end, and the effort somewhere in between.
- See diagrams below.
- Examples of third order levers: shovel, fishing rod, tweezers, tongs.
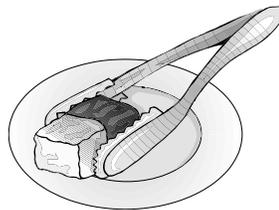
1. **Inclined Plane**
   - An inclined plane is a sloped surface, or a ramp, along which a load is moved.
   - It allows one to overcome a large resistance by applying a relatively small effort across a longer distance than the load actually has to be moved.
   - "Slope" is a measure of the angle by which an inclined plane is elevated from the horizontal.
     - The *greater* the slope, the *less* the advantage: *more* effort is required.
     - The *less* the slope, the *more* the advantage: *less* effort is required.
   - "Effort" is the force required to move the load.

- Examples of inclined planes: ramps, switchbacks, ladders, dump trucks
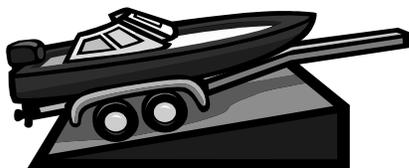
2. Wedge
- A wedge is related to the inclined plane. It is a moving inclined plane.
- Generally it can be anything that splits, cuts, or divides another object (including air and water).
- It tapers from a sharp edge to a blunt end along its longitudinal axis.
- The more gradual the taper, the greater the mechanical advantage.
- A fairly weak force, applied to the wide end of a wedge whose narrow end is being pushed into something, will send a strong force pushing out at the sides.
- Applied to a ship's bow, a wedge divides the water smoothly, minimizing the energy required to push the water away so that the ship can move forward. Sometimes the tapered ends are pointed, and sometimes they are blunt
- Examples of wedges with pointed ends: bullets, nails, pencils
- Examples of wedges with sharp ends: axes, wedges, chisels, shovels, knives, the prow of a boat.

3. **Screw**
- A screw is another form of an inclined plane.
- A screw is an inclined plane (thread) wrapped around a rod to form a spiral.
- This inclined plane allows the screw to move itself or to move an object or material surrounding it when rotated.
- The less the slope on the plane, the less distance there will be between the threads of the screw, and less effort will be required to move the load. While turning, the screw converts rotary motion to forward or backward motion.
- Example: screw, threaded bolt, spiral staircase, screw lid on jar, car or house jack
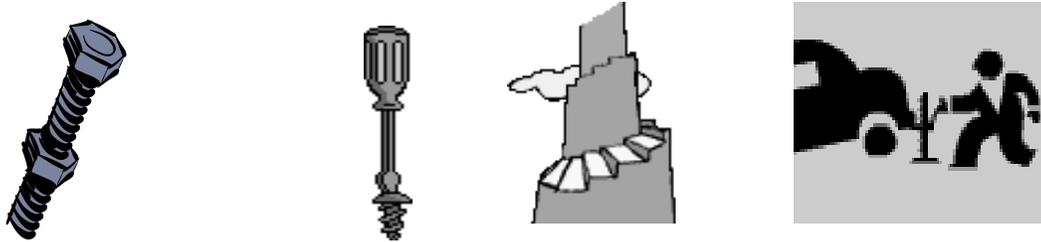
4. **Wheel And Axle**
- A wheel and axle is basically two circular objects of different sizes.
- The wheel is the larger object that turns the smaller object called the axle.
- When the wheel turns the axle, movement is created.
- The wheel is always larger than the axle, so it always moves a greater distance than the axle.
- Mechanical advantage depends on the radius of the wheel and the axle.
- A wheel and axle machine is used in two ways:

   1. To roll something along, cutting down on the amount of friction between the surface and the load. Generally, the bigger the wheel, the easier it is to move the load. Examples: wagon, dolly, truck, roller skates

   2. Like a lever in the round that turns and has the fulcrum in the middle. The larger the diameter of the wheel, the less effort needed to turn it, but it has to be moved a greater distance to get the work done. The amount of work does not change. Examples: door knob, screwdriver, sink faucet, pencil sharpener, hand drill

5. Gears

- Gears are wheels that that have "teeth" or "cogs" on their edges and are used in combinations of different sizes.
- There are different types of gears; the ones in the pictures below are spur gears.
- Intermeshing gears are used to transmit motion or force.
- They are used in three ways:
  1. to multiply or reduce speed and force
  2. to change direction of motion
  3. to transmit a force over a distance
- Gear terms:
  - → Train: A series of intermeshing gears. Gears turn in opposing directions.
  - → Driver: The gear in a train that has the force or motion input
  - → Driven: The gear that has the force or motion output (follower)
  - → Ratio: The number of teeth on the follower divided by the number of teeth on the driver.
  - → Rule: Low gear ratio = more speed = less force
      High gear ratio = less speed = more force.
- Examples of gears in use: wind-up clocks, bicycles, power meters.
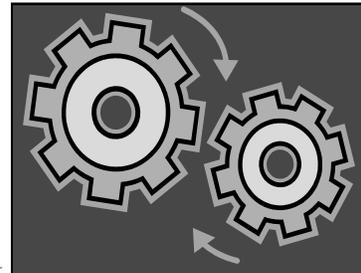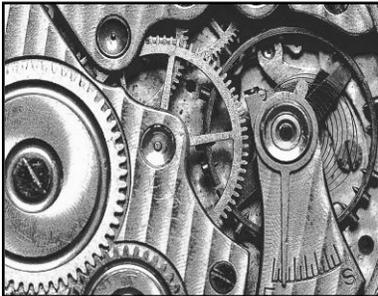
In the picture below, the smallest wheel has 12 teeth, while the largest wheel has 24 teeth. The small wheel rotates twice for each rotation of the large wheel.
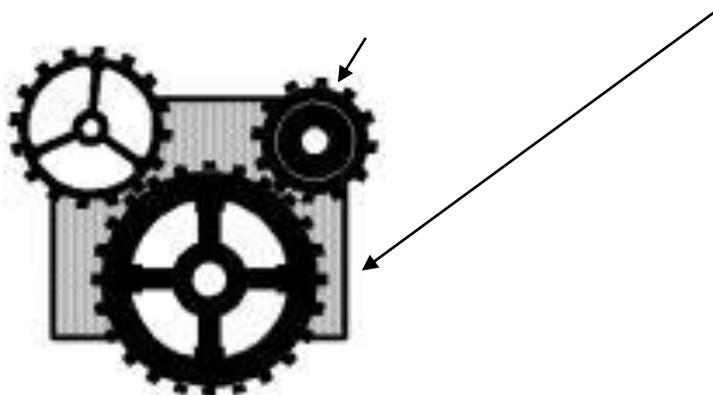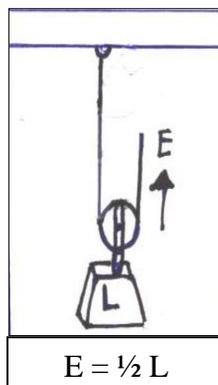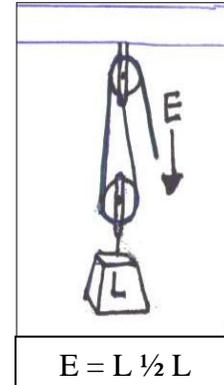
6. Pulley

- A pulley is a rope, chain, cable, or belt that is looped around a wheel. It is actually a wheel and axle with a rope (etc) attached.
- A pulley makes it seem easier to pull something because it changes the direction of the force.
- There are three different types of pulleys:
  1. Fixed pulley, which changes the direction of the lifting force, as in raising a flag on a flagpole or a sail on a mast. The load moves, but the pulley does not. There is no mechanical advantage with this type of pulley: the same amount of effort is required, though it can seem less because of gravity. In fact, the effort is more than the load.
  2. Moveable pulley is one that moves with the load. This type of pulley allows the effort to be less than the load. If you add a second pulley, the effort is even less.
  3. The combined pulley requires less effort to lift the load: the effort is less than half the load. The disadvantage is that the effort travels a longer distance.
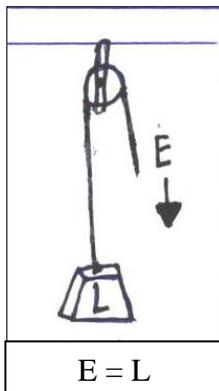
$E = L$	$E = \frac{1}{2} L$	$E = L \frac{1}{2} L$
Single fixed pulley	Single moveable pulley	Combined pulley

Block and Tackle

A block and tackle arrangement is when pulleys are used in combination and the pulley attached to the weight consists of two separate pulleys on the same shaft. This cuts the force in half and doubles the distance. A block and tackle can have any number of pulleys, but at some point, the amount of friction in the pulley shafts becomes significant.

To figure out the effort required to lift the load with a block and tackle, divide the load by the number of ropes used to move it. For example, if the load is 200 grams and there are 4 ropes running through the pulleys, the effort required is $200 \div 4 = 50$.

Compound Machines

Simple machines can be combined to form compound machines, Here are some examples:

- Scissors: wedges (blades) and levers
- Hand meat grinder: wheel and axle (handle) and screw (grooved interior that moves the meat along)
- Wheelbarrow: levers (handles) and wheel and axle

Now you try:

1. A system of cogwheels is shown in the diagram below:

An external force turns the cogwheel on the extreme left in the given direction (counter clockwise). Which cogwheel will turn faster, the first one (I), the second one (II) or both cogwheels will turn at the same speed (III)

2. A tube is attached to the left hand side of a connector. Two tubes, situated one on top of the other, are connected to the right hand side. Water enters the system from the left tube, flows at a constant velocity through the connector, and exits via the two right hand tubes. At which opening is the velocity of water the greatest - 1, 2, 3, 2 & 3 or the velocity is the same at all openings?

3. Two identical triangles are placed inside a water tank as shown in the diagram below. The triangles are fixed in position. On which triangle will a greater force be exerted – 1, 2, or equal on both triangles?
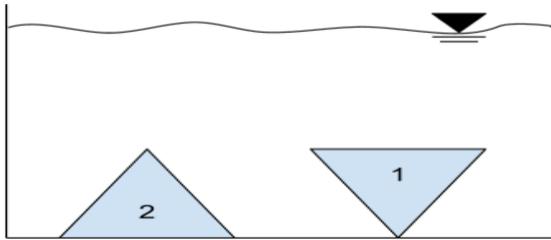

4. The grey cogwheel labelled 1 is being turned at a constant speed in a counter clockwise direction as shown in the diagram. The red cogwheel has 16 teeth whilst the rest of the cogwheels have 12 teeth.
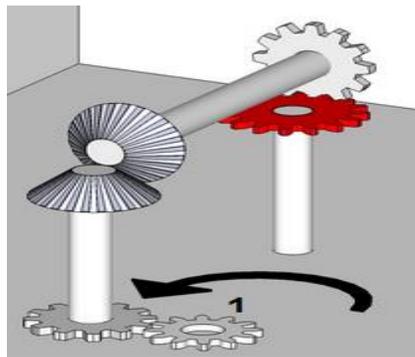
Please choose the statement which correctly describes the rotation of the red cogwheel in comparison to cogwheel 1.

a)clockwise, faster   b)clockwise, slower   c)counter clockwise, faster d)counter clockwise, slower

5. The diagram shows two fixed cogwheels which can only rotate around their own axis. A rack is inserted between the two cogwheels and is moved in the direction shown by the arrow.
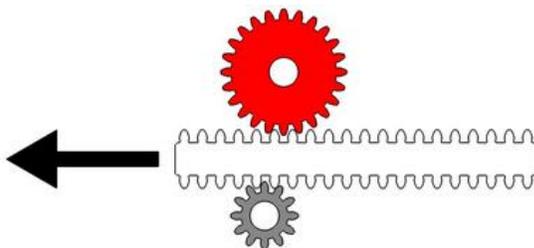
What are the directions of movement and velocities of the cogwheels?
   a) Same direction, same velocities b) Same direction, different velocities
      c) Different directions, same velocities d) Different directions, different velocities

6. Cogwheel number 1 rotates counter clockwise as shown.
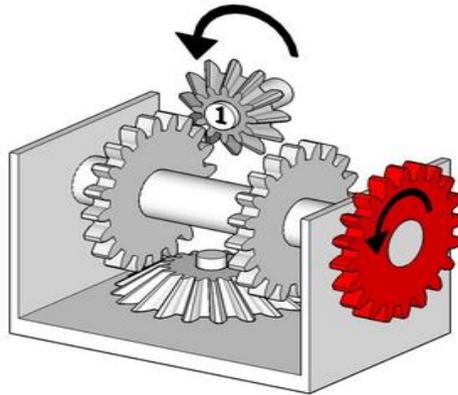
If the red cogwheel rotates in the direction of the arrow choose option 1; if it rotates in the opposite direction choose option 2; if the red cogwheel does not move at all choose option 3.

Adapted from http://www.jobtestprep.co.uk/free-mechanical-reasoning Feb 20th 2015

Answers:

1. II
2. The velocity is the same at all openings
3. Triangle 2
4. b – clockwise, slower
5. d) Different directions, different velocities
6. 3

For more mechanical reasoning practice material go to:

http://www.bcit.ca/files/tlc/pdf/tlc_sampletest_mechreasoning.pdf

http://www.aptitude-test.com/mechanical-aptitude.html

www.psychometric-success.com/downloads/download-practice-tests.htm

Abstract Reasoning:

Abstract Reasoning assesses your ability to identify patterns amongst abstract shapes where irrelevant and distracting material may lead to incorrect conclusions. The test therefore measures your ability to change track, critically evaluate and generate hypotheses and requires you to query judgements as you go along.
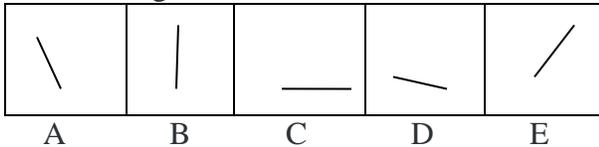
In this part of the assessment, you will see rows of figures or designs. Each question consists of 4 figures called *problem figures* and 5 called *answer figures.* You need to decide which one of the answer figures would be the next or fifth one) in the series of problem figures.

Example 1.

Problem Figures

Answer Figures

A   B   C   D   E
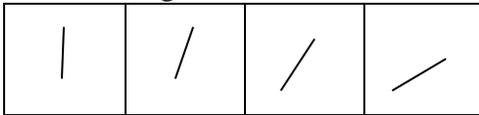
In this example, notice that the lines in the problem figures are falling down. In the first square, the line is standing upright, and as you go from square to square the line falls more and more to the right.
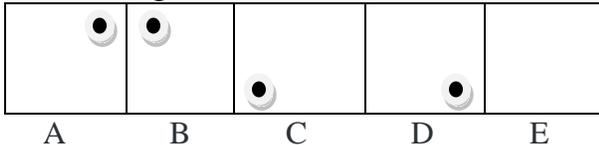
In the fifth square, the line would be lying flat, so the correct answer, chosen from among the answer figures is C

Example 2.

Problem Figures

Answer Figures

A   B   C   D   E
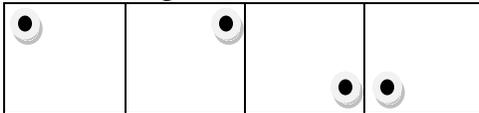
In this example, look at the position of the black dot in the problem figures. The black dot is moving around the square clockwise: upper left corner, upper right corner, lower right corner, lower left corner. In what position will it be seen next?

It will come back to the upper left corner. Therefore, B is the correct answer.

Remember:

➢ Only one of the answer figures is correct.

➢ This part of the assessment requires you to move very quickly, so don't spend too much time on any one question.

For more Abstract Reasoning practice material go to:

https://www.123test.com/abstract-reasoning-test/
http://www.fibonicci.com/abstract-reasoning/test/
http://www.savilleconsulting.com/docs/preparation-guides/preparation-guide-abstract-reasoning.pdf?sfvrsn=2

Spatial Reasoning:

The Space Relations questions measure the ability to visualise a three-dimensional object from a two-dimensional pattern, and to visualise how this object would look if rotated in space. Each problem shows one pattern, followed by four three-dimensional figures. Students are to choose the one figure that can be made from the pattern.
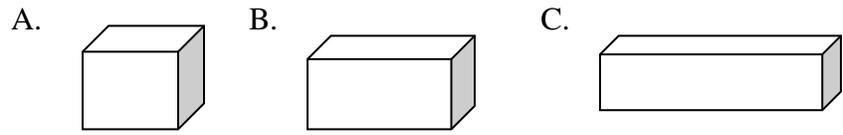
Example 1: Which one of the 4 shapes can be made from this 'cut out'?
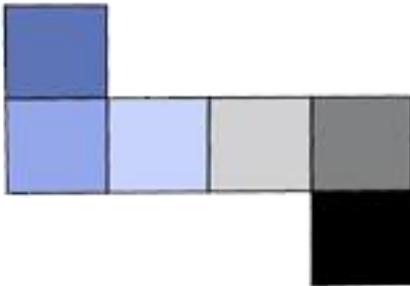
To solve this question you need to fold the 'cut out' in your mind and choose the correct representation. The correct answer to this example is A. Spatial reasoning is important for generating solutions in areas such
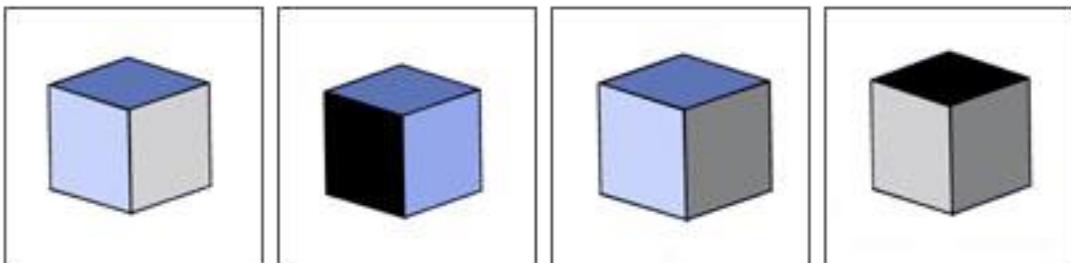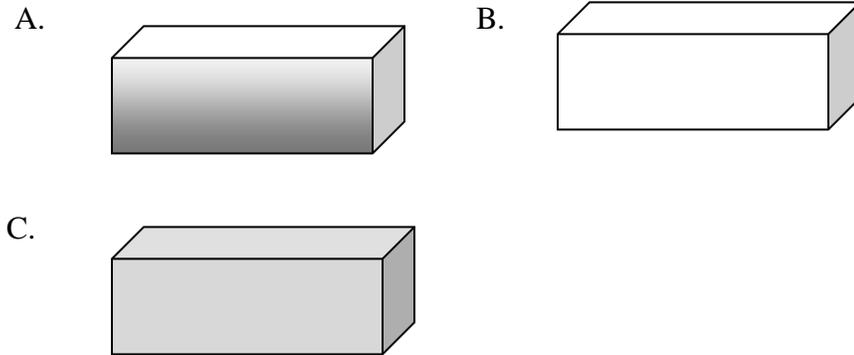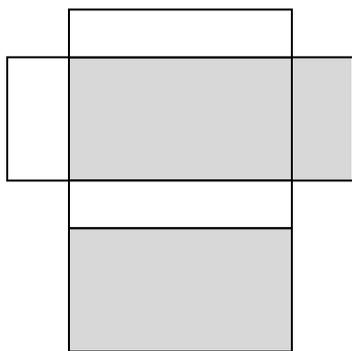
Example 2: Which one of the 3 shapes can be made from this 'cut out'?

Answer = C

Shapes A and B cannot be made as they are not the right shape. C is correct in both shape and size.

Example 3: Which one of the 3 shapes can be made from this 'cut out'?

Answer = A (A large grey surface is shown, and the end surface is also grey)

Shape B is wrong. The two largest surfaces must be grey.
Shape C is wrong. The original cut out has some non-grey sides.

Remember:

➢ The surface you see in the 'cut out' is always the *outside* surface of the completed shape.

➢ Study the 'cut out' carefully and decide which shape can be made from it.

➢ Only one of the shapes is correct.

➢ This part of the assessment requires you to move very quickly, so don't spend too much time on any one question.

For more Space Relations practice material go to:

http://www.aptitude-test.com/spatial-visualization.html

http://www.fibonicci.com/spatial-reasoning/test/
http://www.psychometric-success.com/faq/faq-spatial-ability-tests.htm