TOPIC 4 Machines

1 **The Law of Conservation of Energy basically says that we can't obtain energy in one situation without losing it in another. In other words, we can't 'create' energy. This means that simple machines:**

- **A** always gain a little energy as they operate.
- **B** basically change energy into a more usable form.
- **C** make jobs easier by transforming energy from one form to another without any loss.
- **D** make jobs easier because they give out more energy than they take in.

Levers

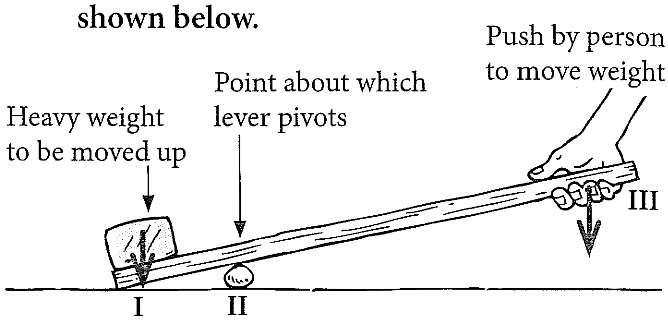
2 **Perhaps the simplest machine is a lever. A lever usually takes the form of:**

- **A** a rigid bar (or equivalent) that pivots on a point and seems to make a task easier.
- **B** a long steel bar used for prising things.
- **C** a very short, hand-held device that assists people without needing a pivot.
- **D** all of the above.

3 **Common devices which are simply levers include:**

- **A** a corkscrew, a wedge and handbrake handles on a bicycle.
- **B** an axe, a paddle and a handbrake handle on a car.
- **C** a ramp, a broom and an oar from a boat.
- **D** a broom, a fishing rod and handbrake handles on a bicycle.

4 **A simple situation involving a lever is shown below.**



In general terms, the names that are used to describe the situations at points I, II and III in the diagram are, respectively:

- **A** load, effort and fulcrum.
- **B** load, fulcrum and effort.
- **C** effort, fulcrum and load.
- **D** effort, load and fulcrum.

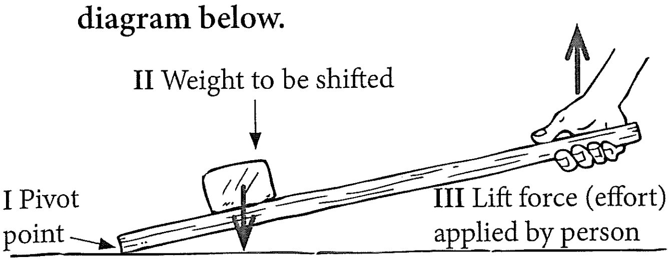
5 **In the situation in Question 4, the distances (or lengths) that we call the 'effort arm' and the 'load arm' are those, respectively, between:**

- **A** I and II, and II and III.
- **B** II and III, and I and III.
- **C** II and III, and I and II.
- **D** I and III, and I and II.

6 **In a single lever system as in Question 4, it is true to say that, if the effort arm is of greater length than the load arm, then:**

- **A** the push force of the person will be less than the weight force to be moved.
- **B** the push force of the person may be less than the weight force to be moved, depending on the size of the weight force.
- **C** no matter what the weight force to be moved, the push force must always be greater.
- **D** the two forces will be of equal size and so 'balance' the weight force.

7 **Another lever system is shown in the diagram below.**



This arrangement of the pivot point, the weight to be shifted and the 'lift force' (effort) by the person:

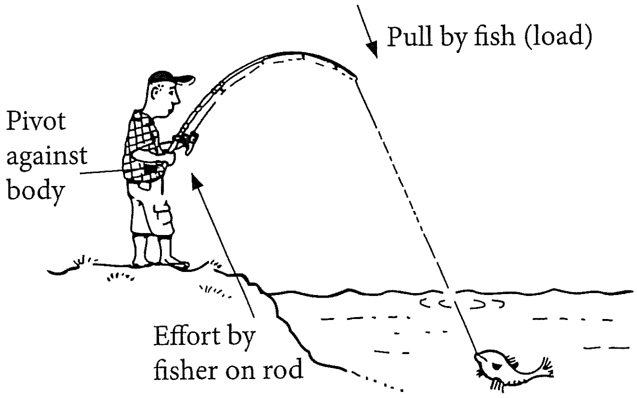
A makes it harder for the person to shift the weight.

B is not used in practice to shift a weight.

C rarely makes it easier to shift a weight.

D still makes it easier for the person to lift the weight.

8 **While most levers try to make the job of moving a load easier (i.e. using an effort less than the load) one type of lever actually makes the job 'harder'. One example of such a lever is a fishing rod.**



A lever such as the fishing rod is used:

A when the load is large and has to be moved through only a small distance.

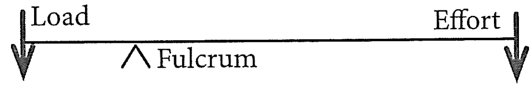
B when the load is small and needs to be moved through a greater distance than the effort of the fisherman.

C when the other types of levers cannot be used in the situation.

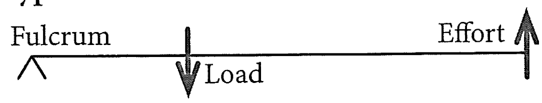
D when too much force is applied by the load for the other levers to cope.

9 **The three types (or orders) of levers can be shown by the arrangement of the fulcrum, effort and load in each case. Diagrammatically, that is:**

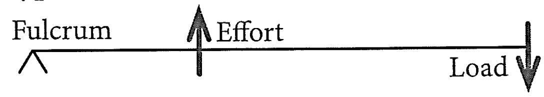
- **Type 1 or 1st order lever**



- **Type 2 or 2nd order lever**



- **Type 3 or 3rd order lever**



The reason Type 1 and Type 2 levers seem to make tasks easier is because:

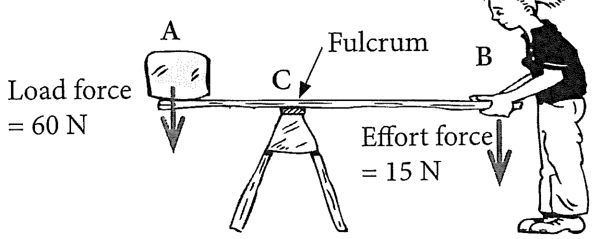
A the fulcrum is not necessarily at the end of the lever.

B of the direction of movement of load and effort.

C the effort arm in each case is longer than the load arm.

D the load arm in each case is longer than the effort arm.

10 **The measure of a lever making a job usually somewhat easier is called the Mechanical Advantage (M.A.) of the lever. This is basically defined as:**
M.A. = Load force / Effort force.
It is also measured by:
M.A. = Length of effort arm / Length of load arm.



This means that, in the diagram above:

A the M.A. is 4.

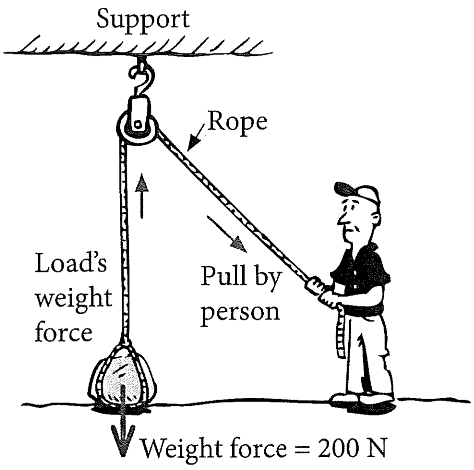
B the M.A. is 1/4.

C the distance CB would have to be 2 × the distance AC.

D the distance AC would have to be greater than the distance CB.

Pulleys

11 The machine called a 'single fixed pulley' is shown in the diagram where a load of 200 N is being lifted off the floor by a person pulling a rope.



In this situation, the advantage that the person gains is:

A because the pull required is less than 200 N.

B simply a change in direction of the force needed to lift the load.

C such that a pull of only 100 N is needed.

D due to the pulley taking some of the load.

12 When the person does lift the load in question 11 off the floor, the pulley support would experience a force downwards of approximately:

A 200 N. B 600 N.

C 100 N. D 400 N.

13 If in the situation shown in question 11, the load of 200 N is lifted 2 m above the floor, the amount of rope pulled through the pulley by the person would be:

A 4 m.

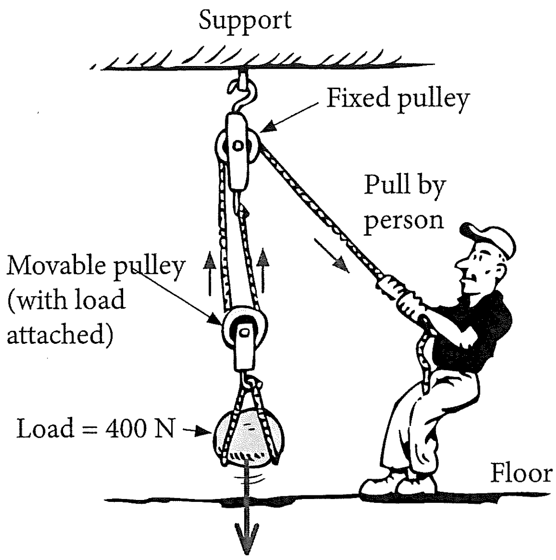
B 1 m.

C 2 m.

D dependent on the size of the pulley.

Questions 14–16 refer to the following information.

Another pulley system is the one called a 'single movable pulley'. It also involves the use of a 'single fixed pulley'. This arrangement is shown in the diagram, with a load of 400 N. The load is attached to the 'movable' pulley which has 2 ropes supporting it.



14 This arrangement means that the pull by the person:

A would be the same as with the 'single fixed pulley'.

B is about 200 N, i.e. about half the load, since 2 ropes support the load.

C is greater than 400 N.

D is only $\frac{1}{3}$ of 400 N.

15 In this situation, the pull or effort by the person:

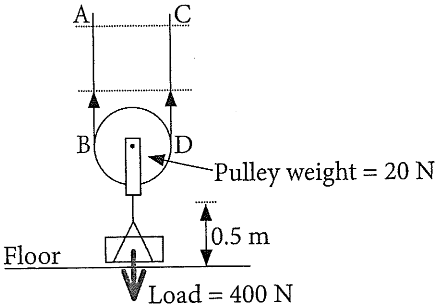
A is partially used in lifting not only the load, but the movable pulley too.

B would move the load 2 m upward if 2 m of rope were pulled downward by the person.

C could only move a maximum load of 400 N, no matter what the effort (pull) applied.

D is restricted by the weight of the single fixed pulley.

16 **The part of the diagram involving the load is shown in a separate diagram below. The goal is to lift the load, which is on the floor, by a distance of 0.5 m using the single movable pulley system.**



For this to be achieved:

A 0.5 m of rope has to be pulled down by the person.

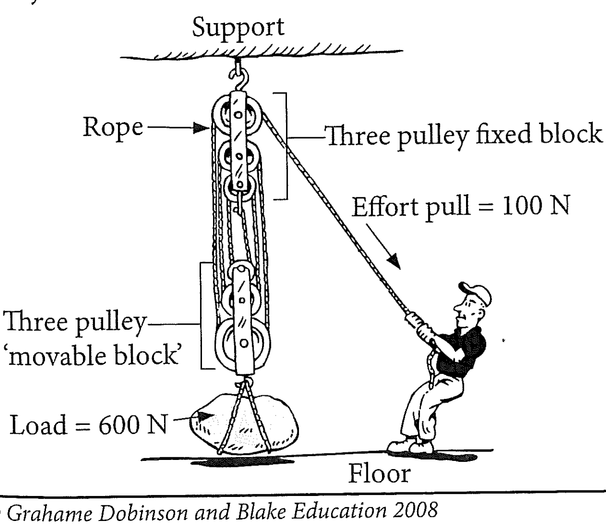
B only the rope on side AB has to be shortened by 0.5 m.

C only the rope on side CD has to be shortened by 0.5 m.

D both the rope sections, i.e. sides AB and CD, have to be shortened by 0.5 m.

Questions 17–18 refer to the following information.

A single movable pulley makes the job of lifting heavy loads easier, because a smaller effort can be used. Therefore, this combination of pulleys can be expanded for even greater effect. A 'block' of fixed pulleys can be connected to a 'block' of movable pulleys to lift or move a very large load. In this example, there are 3 pulleys in each block, connected as shown in the diagram. (The pulleys are shown under one another, but are usually side by side). If we ignore the weight of the movable block, then the person exerting an effort of 100 N can just lift the load from the floor.



17 **The effort required can best be explained by the fact that:**

A the M.A. of the system is 6.

B each of the ropes supporting the movable block exerts an upward force of 100 N.

C both A and B are true.

D the M.A. of the system is 1/6.

18 **In reality for this situation, if the movable block itself weighed 60 N the effort needed to lift the load + movable block would be:**

A 160 N.

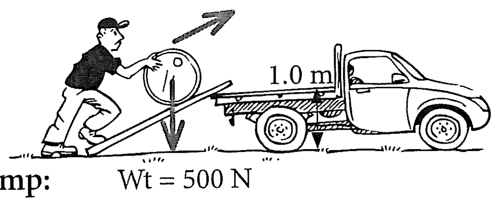
B 110 N.

C 90 N.

D still 100 N.

Inclined planes

19 **The diagram shows a person rolling a heavy cylinder of weight 500 N up a ramp, onto the back of a truck.**



This ramp:

A would enable the person to move the cylinder up the ramp using a force less than 500 N.

B is not really what we would call a proper machine.

C still makes the effort by the person equal to 500 N.

D would have to be extremely long to give any mechanical advantage at all.

20 **To obtain a M.A. > 1 for the situation in question 19, the:**

A effort would have to be less than 250 N.

B effort would have to be more than 250 N but less than 500 N.

C length of the ramp would have to be at least 2 metres.

D ramp could be inclined to the road at any angle less than 90°.

21 Three examples of devices which give us some assistance because they are really versions of inclined planes are:

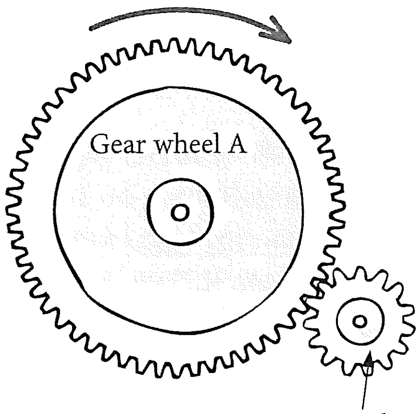
- A a corkscrew, a wedge and a knife.
- B a corkscrew, a hammer and a knife.
- C a wedge, a hammer and a knife.
- D a screwdriver, a wedge and an axe.

Gears

22 The purpose of using gears in any machine is to:

- A use less energy to shift a load.
- B always change the direction of an applied effort.
- C always increase the speed at which a load can be moved.
- D provide energy at a more suitable rate.

23 Gears often involve 'cogged wheels' (i.e. interlocking wheels) to transmit energy from one wheel to the other. Two such gear wheels are shown in the diagram. Gear wheel A has 60 'teeth' and gear wheel B has 15 'teeth'.



This means that, when gear wheel A turns clockwise one complete revolution, gear wheel B would turn:

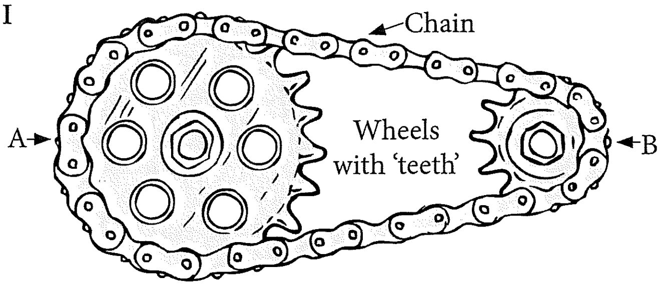
- A clockwise through four revolutions.
- B clockwise through one revolution.
- C anticlockwise through four revolutions.
- D anticlockwise through one revolution.

24 In the diagram in question 23, it would be true to say that if an effort (E) were applied to rotate the cogs on wheel A, the load that could be moved by wheel B would be:

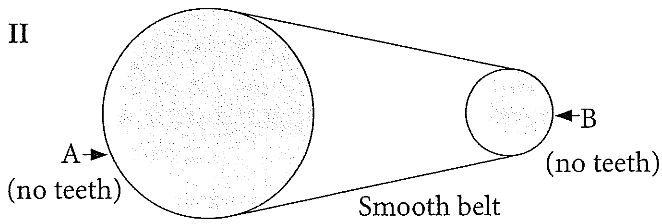
- A $2 \times$ E.
- B $4 \times$ E.
- C $\frac{1}{4}$ E.
- D $\frac{1}{2}$ E.

25 Sometimes gear wheels are not connected directly, but by a belt or chain which runs around them, as shown in the diagrams.

I



II



In situations like this, if gear wheel A rotates clockwise then gear wheel B will:

- A rotate anticlockwise at a faster rate in situation (i) but not in (ii).
- B rotate anticlockwise at a faster rate in situations (i) and (ii).
- C rotate clockwise at a slower rate in situations (i) and (ii).
- D rotate clockwise at a faster rate in situations (i) and (ii).

26 When a bicycle is being ridden on flat ground, the situation with a bicycle gearing system is most similar to that shown in question 25, diagram:

- A (i), where the pedals drive gear A.
- B (i), where the pedals drive gear B.
- C (ii), where the pedals drive gear A
- D (ii), where the pedals drive gear B

Efficiency

27 When the term 'efficiency of a machine' is used, it relates to the energy which goes into the machine compared to the energy which comes out of the machine. This is usually expressed as a percentage:

$$\text{Efficiency} = \frac{\text{Energy out}}{\text{Energy in}} \times \frac{100}{1}$$

If a machine has an efficiency of 30%, this would mean that:

A most of the energy put into the machine is not converted to a usable output.

B if 200 joules of energy went into the machine, then only 60 J would be available as usable energy output.

C the machine is very inefficient.

D all of the above statements are true.

28 The internal combustion engines which burn fuels such as petrol or diesel and are used to power most motor vehicles are generally very inefficient, usually well under 30% efficiency. The (i) energy conversion we are seeking and (ii) the main reason for the low efficiency, respectively, are:

A (i) chemical energy to kinetic and (ii) there is great heat loss in such engines.

B (i) chemical energy to kinetic and (ii) there is only a small amount of energy available from such fuels.

C (i) chemical energy to potential and (ii) there is great heat loss in such engines.

D (i) chemical energy to kinetic and (ii) the majority of energy from the fuel is converted to unwanted sound energy.

29 If a machine is described as 50% efficient then it would:

A prevent more than 50% of energy from being wasted.

B produce 150 joules of usable energy from an input of 300 joules of energy of a different type.

C lose half of the energy put into it because of conversion to unwanted forms of energy.

D produce the effects described in both B and C above.

30 For a particular machine, the energy input by way of the stored energy in a fuel and the energy outputs of different forms of energy are summarised in the table.

Energy input (J)	Energy output (J)
5000 as available energy stored in fuel	Kinetic: 1000 Heat: 3000 Sound: 600 Light: 400

The machine carrying out the conversion is:

A most efficient in producing kinetic energy.

B 20% efficient in producing kinetic energy.

C producing mainly kinetic, sound and light energy.

D only 10% efficient in producing light energy.

ANSWERS

Topic 1 – Waves

1 C	2 A	3 B	4 D	5 B
6 D	7 B	8 C	9 D	10 C
11 A	12 B	13 A	14 A	15 D
16 B	17 B	18 B	19 C	20 C
21 A	22 D	23 B	24 C	25 B
26 A	27 D	28 C	29 B	30 A
31 C	32 D	33 A	34 C	35 B
36 A	37 B	38 C	39 B	40 A
41 C	42 B	43 B	44 A	45 D
46 B	47 C	48 B	49 D	50 D
51 A	52 B	53 D	54 C	

Topic 2 – Electricity

1 B	2 B	3 C	4 C	5 D
6 B	7 D	8 C	9 D	10 B
11 D	12 C	13 A	14 A	15 C
16 A	17 A	18 C	19 C	20 B
21 C	22 A	23 A	24 C	25 B
26 D	27 A	28 D	29 C	30 A
31 D	32 B	33 B	34 A	35 C
36 B	37 D	38 C	39 D	40 A
41 C	42 C	43 B	44 D	45 D
46 C	47 A	48 D	49 B	50 C

Topic 3 – Motion

1 B	2 C	3 A	4 D	5 A
6 B	7 B	8 C	9 D	10 A
11 B	12 D	13 C	14 A	15 D
16 B	17 C	18 B	19 D	20 B
21 D	22 B	23 C	24 A	25 B
26 A	27 A	28 D	29 C	30 B
31 A	32 C	33 D	34 B	35 C
36 A	37 B	38 B	39 A	40 C
41 B	42 D	43 A	44 C	45 B
46 C	47 D	48 B	49 A	50 A
51 B				

Topic 4 – Machines

1 B	2 A	3 D	4 B	5 C
6 A	7 D	8 B	9 C	10 A
11 B	12 D	13 C	14 B	15 A
16 D	17 C	18 B	19 A	20 D
21 A	22 D	23 C	24 B	25 D
26 A	27 D	28 A	29 D	30 B

Topic 5 – Nuclear energy

1 B	2 C	3 D	4 A	5 A
6 B	7 C	8 D	9 A	10 B
11 C	12 A			

Topic 6 – Fields

1 B	2 A	3 D	4 C	5 A
6 D	7 D	8 D	9 D	10 B
11 A	12 C	13 B	14 A	15 D

Topic 7 – Light

1 B	2 D	3 A	4 A	5 C
6 C	7 C	8 B	9 D	10 A
11 A	12 B			

Topic 8 – Sound

1 D	2 B	3 A	4 A	5 C
6 D	7 D	8 A	9 B	10 C
11 A	12 B	13 D	14 C	15 D
16 C				