**Physics: 11. Moments**

***Please remember to photocopy 4 pages onto one sheet by going A3→A4 and using back to back on the photocopier***

**Syllabus**

**OP9** Investigate the law of the lever; recall two everyday applications of levers

**Student** **Notes**

**A lever is a rigid object which is free to turn about a fixed point called a fulcrum.**

**Everyday applications of levers**

Seesaw, scissors, door handle, wheel-barrow, spanner, etc.

(Can you identify the fulcrum in each case?)

**The Moment of a force = the force × distance (between the force and the fulcrum).**

**Example**

A force of 75 N is used to turn the spanner in the diagram. If the distance between the force and the nut is 10 cm calculate the moment of the force.

Answer

Moment = Force x distance

 = 75N × 0.1 m

 =7.5 N m

What would be the effect of using a longer spanner?

**The Law of the Lever:**

**When a lever is balanced, the clockwise moment acting on it is equal to the anti-clockwise moment acting on it.**

**Experiment: To Verify the Law of the Lever**



Procedure:

1. Hang a metre stick from the 50 cm mark as shown.
2. Attach two weights and adjust their positions until the metre stick balances.
3. Note the position and force of each object.
4. Show mathematically that the force multiplied the distance clockwise equals the force multiplied by the distance anti-clockwise.

**Exam Questions**

1. [2010 OL]
2. Which of the following items does not involve a lever?
3. Give a reason for your answer.



1. [2007]

Give an everyday example of an application of the lever, using a labelled diagram, showing the fulcrum and at least one force acting on the lever.



1. [2011 OL]

The diagram shows a spanner and a nut. Complete the sentences below:

1. The further away from the fulcrum (turning point) you apply a \_\_ the easier it is to turn a nut.
2. The use of a spanner to turn a nut is an everyday example of using a \_\_\_\_\_ .
3. [2011]

The door handle is an application of a lever.

The labels and arrows show three points.

Which of the points A, B or C represent:

1. The fulcrum (turning point)
2. The point where the smallest force will open the door lock.



1. [2008 OL]

The crowbar in the diagram acts as a lever and applies a turning force on the boulder (large rock).

Answer the questions which follow with reference to the points A, B and C in the diagram.

1. Which of the three points, A, B or C, is the fulcrum (the point about which the turning force acts)?
2. At which of the three points, A, B or C, will the least force be needed to move the boulder?

Give a reason for your answer.

1. [2007] Define moment of a force.
2. [2008] State the law of the lever.
3. [2010]

A uniform metre stick, suspended at its mid-point is balanced as shown.

Calculate force X.

1. [2007]

A metre stick is suspended from its centre of gravity which is at its midpoint.

A force of 3 N acts on the stick at the 90 cm mark and a force of F newtons acts on the stick at the 20 cm mark. Calculate force F.

**Exam Solutions**

1. Traffic cone
2. It has no fulcrum / no pivotal point / doesn’t rotate about a point.
3. One example would be a spanner, see diagram
	1. The fulcrum is indicated.
	2. The force would be applied by hand to the position indicated because the lever is longest at this point.
4. Force
5. Lever
6. A
7. C
8. C
9. A – it it farthest from the fulcrum
10. Moment of a force is equal to the force multiplied by the distance between the force and the fulcrum.
11. When a lever is balanced the clockwise moment (turning effect) equals the anticlockwise moment.
12. 30 × X = 3 × 40

X = 4 N

1. 30 × F = 40 × 3

F = 4 N

**Other Test Questions**

1. What is a lever?
2. Draw a diagram of a scissors and indicate where the fulcrum is.
3. Give two other examples of a lever.
4. A wrench 30 cm long is used by a mechanic to turn a nut. If the force he exerts on the end is 5 newtons.

Calculate the moment of the force.

1. A boy held a book of weight 50 newtons in his fully outstretched hand, at a distance of 50 cm away.

Calculate the moment of the force.

1. A wrench 50 cm long is used to turn a nut.

If the force exerted on the other end of the wrench is 20 N calculate the moment of the force.

1. Beyonce weighs 500 N and is sitting at one end of a see-saw which is 4 m long and balanced in the middle.

Jordan is 2000 N. Where should she sit in order to balance the see-saw?

1. A metre stick is balance in the middle and has a force of 8 N hanging from the 20 cm mark. What force needs to hang from the 60 cm mark in order to balance the metre stick?

**Teaching *Moments of a force***

**Syllabus**

**OP9**

Investigate the law of the lever; recall two everyday applications of levers

**OP9:**

**Investigate the law of the lever; recall two everyday applications of levers**

* 1. **Definitions**

It’s not clear from the syllabus, but based on exam questions it would appear that the student is expected to be familiar with the following definitions:

* **The moment of a** **force** is equal to the force multiplied by the distance between the force and the fulcrum.
* **The fulcrum** is the part about which the lever turns.
* **A Lever** is any rigid body which is free to turn about a fixed point called a fulcrum.

Examples of levers: scissors, a door, a wheel-barrow etc

* **The Law of the Lever:**

When a lever is balanced by a number of forces, the sum of the clockwise moments acting on it is equal to the sum of the anti-clockwise moments acting on it.

**1.2 The moment of a force**

Get a female student to close a door by pushing with one finger at the outside while a big male student tries to prevent her by pushing in the opposite direction with his finger just beside one of the hinges.

The girl wins every time.

This should make students realise that the effort needed to make an object rotate depends both on the force applied and the distance between the force and the fulcrum.

I usually mention that when engineers design escape-hatches they need to take this sort of thing into account.

**Try to avoid using the word 'moment' until the concept of 'the turning effect of a force' has clicked.**

**1.3 Maths Problems**

Moment of a Force = Force × distance

Students should be able to answer all the maths questions on this topic from the textbook and workbook.

Note that the most common mistake by students is to use the number written on the metre stick as the distance, instead of calculating the distance between that point and the fulcrum.

**Experiment: To Investigate the Law of the Lever**

* This is not a mandatory experiment but should be written up as a ‘substitute’ in case a student is absent for another mandatory experiment.
* Students seem genuinely impressed when they get the numbers to work out.
* To introduce the experiment there is a demonstration lever with masses in the Resource room.
* You may need to revise the concept of Weight being a force, and that Weight = mass (in kg) × 10.
* This can be a notoriously inaccurate experiment so I have gone to a little trouble to try and improve things.

I have left 12 metre sticks in the Resource room, which have been altered such that the centre of gravity is at the 50 cm mark. I have done this by drilling holes in them, but a quicker (although less permanent) method would be to use blue-tack.

* I have provided a set of nails set into timber holders to ensure the metre stick rotates in one plane only, rather than hanging it from a thread.
* To reduce percentage error, I have left a set of masses in the Resource room which are multiples of 100 grams. Junior cert students can regard each of these to be one Newton (as are the hangers).
* To keep the experiment simple I suggest beginning with something like 200g on one side and 400g on the other.
* When hanging the masses, it can prove tricky to read the position of the hanger if it is hung over the metre-stick directly. It also tends to make the metre-stick turn over. I find it easier use string loops, or large paper-clips which can slide over the metre stick as required, and the weights hang off of these.
* It is worthwhile to do one run as a demonstration.
* Prepare the students for the fact that the numbers are unlikely to work out exactly in this experiment but that this is okay and indeed is true for all experiments in science.
* Note that the most common mistake by students is to use the number written on the metre stick as distance, instead of calculating the distance between that point and the 50 cm mark.
* You may wish to photocopy the table below, or put something similar on the board.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  | Moment Clockwise |  |  |  | Moment Anti-Clockwise |
|  | Weight(N) | Distance(metres) | *Force x Distance* |  | Weight(N) | Distance(metres) | *Force x Distance* |
| Run No. 1 |  |  |  |  |  |  |  |
| Run No. 2 |  |  |  |  |  |  |  |
| Run No. 3 |  |  |  |  |  |  |  |

* This can now be taken a step further by presenting the class with an unknown weight (e.g. a rubber bung or a set of keys) and challenging them to come up with its weight.

At the end the keys are weighed and the students who came closest are the winners!