Dr. Abram Teplitskiy – Students Corner #3.
LEVER – THE SIMPLEST, YET VERY HELPFUL MACHINE!

On our previous meeting in Student's Corner we discussed very important question – how to generate electricity, using energy of Sun, Water, Wind, and different types of mechanical motion. Now we'll introduce the simplest machine ever – lever, and we'll discuss ways of how lever helps people. We are sure that everybody knew what is a lever from swinging on seesaw, what is illustrated in Fig.1. Seesaw, which is shown in the Fig.1-a, consists from a long board, which in the middle of its length is supported by vertical board, so that without children from both sides of the vertical board the long board is keeping equilibrium position. The vertical board in the middle has a special title – ***FULCRUM***, and in technical literature fulcrum also is named a ***PIVOT***.

a

b

Fig.1.General Look of Seesaw

a – children Swinging on Seesaw; b-set of 3 seesaw

Courtesy of Free Internet Wicipedia Encyclopedia, article "Seesaw"

Children all over the world are enjoying swinging on seesaw, but for swinging usually it is necessary to have at least one child on each of seesaw sides. But if you are at home alone, what to do? In this case it would be very helpful your inventiveness. Look on the pictures above, and think if on the left end of seesaw are three children, and on the right end - nobody, how you can swing? We hope that some of our readers will get an idea to put on the right end weight, which approximately equals to the combined weight of the children from the left side. If you got same idea, you are potential inventor, such solution had been patented recently and its scheme is shown in Fig.2.

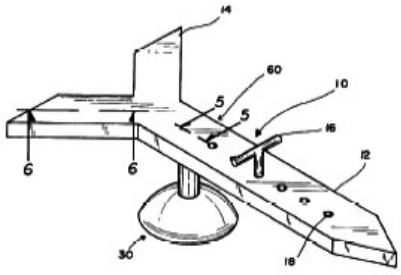


Fig.2. Scheme of Solo Seesaw

Public Domain – US Patent #5,776,002

10 –Solo Seesaw Device, 12 –seat lever arm, 14 – counterweight lever arm,

16 - handle, 30 – Fulcrum, 60 – seesaw body.

We hope that everybody would be able to transform usual seesaw in SOLO seesaw, and enjoy swinging even while home alone. What do you think, could it be invented other type of solo seesaw, which would operating on the basis of other principles? To make a try, think about using a spring, which will act as counterforce, if it would be placed under one of lever arms? Thinking could take time, so let's use it to travel through the LEVER country.

The earliest remaining writings regarding levers dated by 3rd century BC and were provided by Archimedes. ***Give me the place to stand, and I shall move the earth*** - is a remark of Archimedes who formally stated the correct mathematical principle of levers, which is illustrated in Fig.3 below.

Fig.3 - Ahhimedes With his Dream Lever

Courtesy of Free Internet Wicipedia Encyclopedia

In ancient Egypt, construction workers used levers to move and uplift obelisks weighing more than 100 tons. The general scheme of the lever is shown in the Fig. 4.

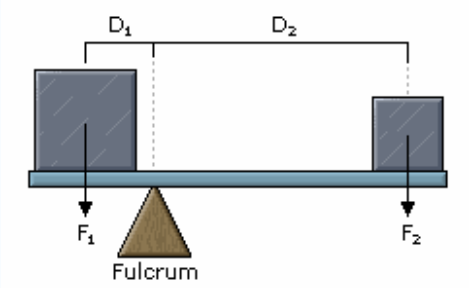


Fig.4. General Scheme of the Lever.

Courtesy of Free Internet Wikipedia Encyclopedia

Mathematically the general equation of a lever, which is in equilibrim position, is as follows:

$$F1 * D1 = F2 * D2,$$

Where F_1 and F_2 – Forces, which acts on the left and right side of a lever correspondingly; D_1 and D_2 – Distances between centers of Gravity of weights on corresponding sides of a lever and center of the Fulcrum.

Levers are classified in three main classes, which are illustrated below. Fulcrum at first class lever is located between points of Input and Output, or corresponding forces as shown in the Fig. 5.

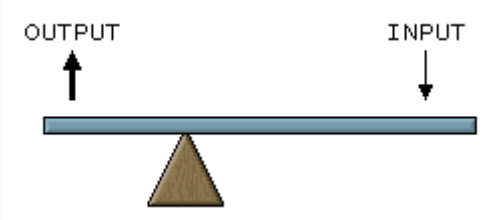


Fig.5. General Scheme of a First Class lever

Courtesy of Free Internet Wicipedia Encyclopedia

If you will pull or pushh a section of a bar, it will cause the lever to swing about the fulcrum, overcoming the resistance force. Examples of first class of a lever are seesaw, shown above, and scissors, shown below in Fig. 6.

Fig. 6. Different types of Scissors are helping people in life.
Courtesy of Motiar Ruhman

Scissors were invented in the Third Century B.C. in Egypt, and first scissors were made of bronze. To make the idea of lever more clear, let's analyze scissors by US Patent 6,651,345.

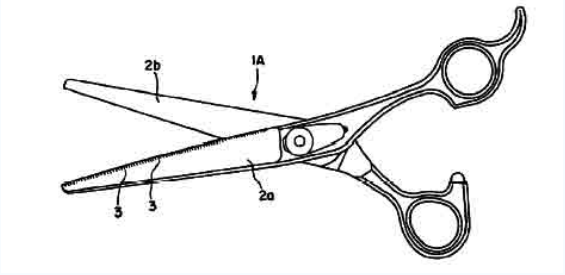


Fig.7. General Sheme of Scissors

Public Domain – US Patent 6,651,345.

From the picture above we can see that scissors contain of two identical elements, which are placed across each other, and connected by fulcrum, which as pin is placed through holes in each element.

Structure of a second type of lever is shown in the Fig.8, and it describes simple machines, which has fulcrum at one of its edges, input of force applied to a handle at other edge of a lever, and output could be taken at any point in between a them.

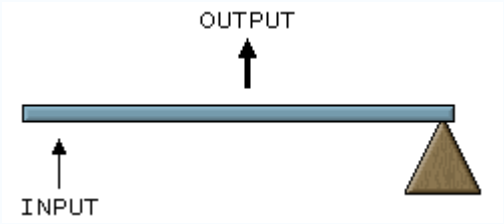


Fig. 8. General Scheme of a Second Class lever

Courtesy of Free Internet Wicipedia Encyclopedia

Examples of this type of lever are weelbarrow or Nutcracker. Levers of a second type are also called “doublelevers”.

Most “populated” is the third class of levers. Among “members” of this third “class” are human arm, catapult (catapults also can act as a see-saw), fishing rod, baseball bat, shovel, broom, etc. Scheme of a third class levers and examples it its ‘action” in life are shown below in Figs.9, 10 and 11. Now a light exercise: considering pencil as a lever, try to estimate how many such “lever writing tools” are in use in USA, and in general in the world every day. Than estimate amount of pencils in your native state, and propose this information and a novel advertisement slogan to companies, which manufacture pencils.

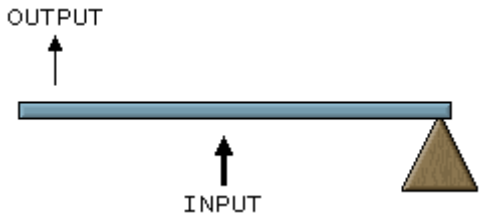


Fig.9. General Scheme of ThirdClass lever

Courtesy of Free Internet Wicipedia Encyclopedia

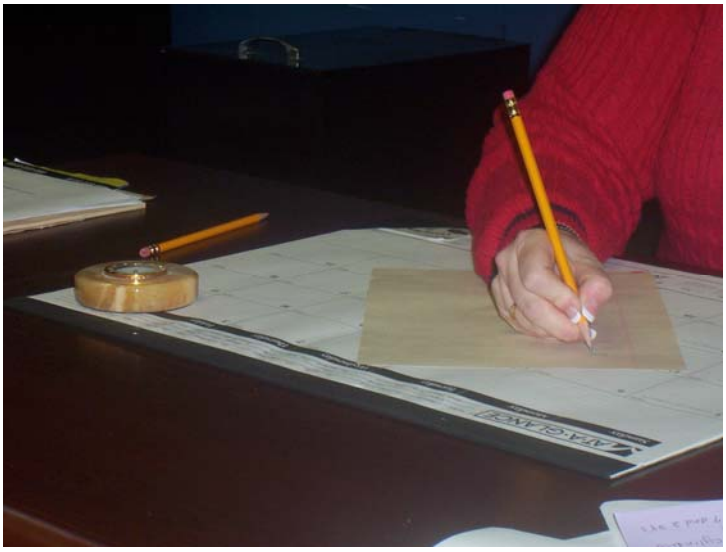


Fig. 10. Pencil while writing is a lever
Courtesy of Jennifer Sanders and Motiar Ruhman

Fig.11. Nail extracting hammer is a lever
Courtesy of Motiar Ruhman

Now let's analyze a problem, which was solved, using knowledge about levers, by students in our special class for young inventors. In construction and in other branches of industry often it is necessary to measure density of structures layer–by-layer. For example, in construction 3D block could contain inside a polymer

layer. It was a real problem how to measure the density of each layer of such a block. When we announce this problem students immediately started to propose usage of X-rays and other methods of Nuclear Era. But we advice them that on construction site it is very difficult to use such stationary equipment, and advice them to look back in time and use tools from Archimedes Era. Because of training students got in inventing class, they collectively proposed to use the lever principle, which is illustrated in the Fig. 10.

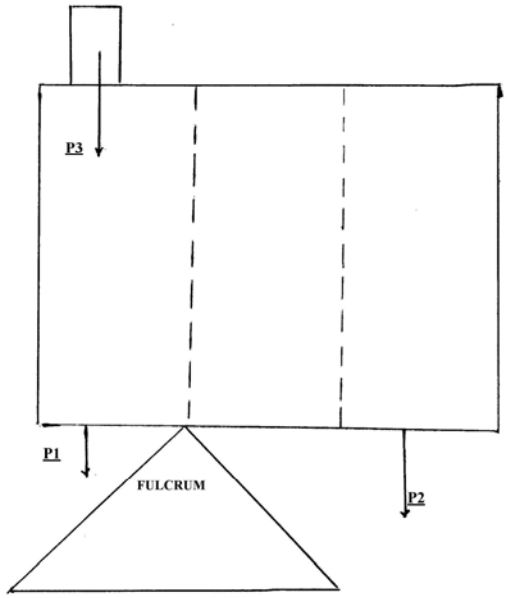
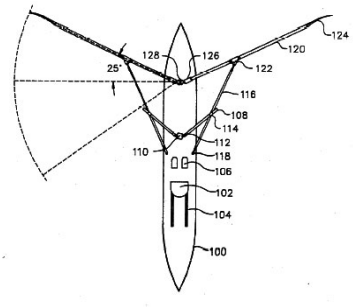
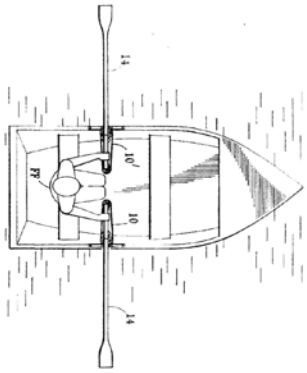


Fig.10.Scheme of Lever-Based Layer-by-Layer Densitometer
Courtesy of Igor Endovtsev

Each type of construction panels has regular form, it was proposed to place under one side of a panel a fulcrum, and move a known weight along the panel until finding position of equilibrium. Using Archimedes equations for equilibrium, we can get first equation, which would contain unknown density of material of construction block. Repeating such “equilibrium” operations under different positions of fulcrum and determining weights, which would bring this system to equilibrium, finally students determined average density and distribution of the density along the panel.

Finalizing our third meeting, we would like to attract your attention to one more example of levers – boats for rowing, examples of which are shown in Fig. 11.





Public Domain – US Patent #5,215,482. **Public Domain – US Patent #5630.739**

Fig.11. General Scheme of Face-Forward Rowing Boats

What we would like to consider as homework for you is:

- Analyze, please, boat for face ahead-boating, which are shown in the Fig.11, classify to what type of a lever they belong;
- Try to propose your own structure of face-ahead boating;
- Propose any application of levers in school, and in general, in life.

Happy Inventing!