

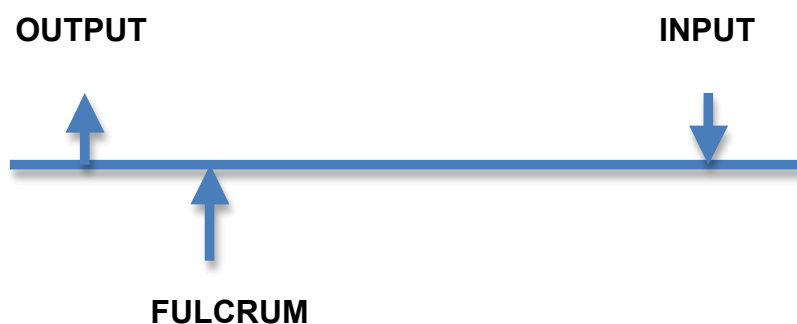
No 4 Levers and the position of mechanical advantage

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1. Today, I am going to look the principle of the lever and how it underlies the mechanical working of the body. I will also look at what engineers and scientists mean by mechanical advantage.
2. Then I am going to look at what Alexander meant by his phrase *position of mechanical advantage* and some of the ways it can cause confusion.
3. So we start with the principle of the lever. The word lever, incidentally, comes from the French *lever* to lift.
4. In its simplest form, a lever is basically a seesaw. There is straight bit and there is the support on which it is balanced – called the fulcrum.

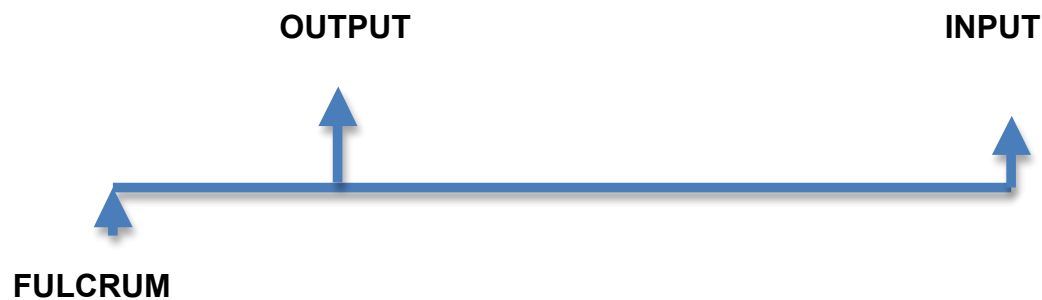


5. Conventionally, one side is referred to as the INPUT – the place where the push is applied and the other side is referred to as the OUTPUT.
6. If I am facing the problem of raising something really heavy from the ground and I am able to find a lever and a fulcrum I am in business. I stick one end of my lever under the thing to be lifted, I put my fulcrum under the lever, and I apply a force at the other INPUT end of the lever. And up comes the thing I want to lift.
7. We know from experience that the distance away from the fulcrum is important. The further away from the fulcrum, the INPUT force, the heavier the weight it can raise at the other side. Archimedes said “*Give me a lever long enough and a fulcrum strong enough and single-handed I can move the world.*”

8. The ability of the lever to allow us to use a small downward force to apply a larger upward force is usually referred to as the mechanical advantage of the lever.
9. Lets us take a simple lever like this in which I am using a force of 1 tonne to lift a force of 10 tonnes. In this case we would say the lever gives us a mechanical advantage of 10.
10. There is, of course, a price to be paid for this mechanical advantage. It is that the distance of movement of the levering force is considerably greater than the amount of movement of the resisting force. A lever enables us to use a small force moving through a certain distance to move a larger force through a shorter distance.
11. This type of lever with the fulcrum between the INPUT and the OUTPUT is known as a **first class lever**.
12. When we look around, we see we are applying the principle of the first class lever all the time. Gardeners use it, for example, when they rest the spade on their knee and bear down on the handle to lift a heavy lump of soil. When we use a screwdriver to lever off the lid of a tin of paint we are using it.
13. We can also join two first class levers together so that each one acts as the fulcrum for the other - as we do in a scissors. If we look at a small pair of scissors, like a nail scissors, we have two miniature levers working together to cut our nails.
14. Then we have the shears, or garden clippers, which are used for cutting the hedge. One of the things we notice about using a garden clippers is that there is usually a notch in the blades at the top of the blades. We can use this notch to hold a tough branch for cutting.

With the branch held in the notch, we can move our hands out along the handle as far as possible. This maximises our mechanical advantage and allows us to apply a much greater force at the notch which cuts through the wood.
15. But there are other kinds of levers. The next one we will look at is called a **Second class lever**.

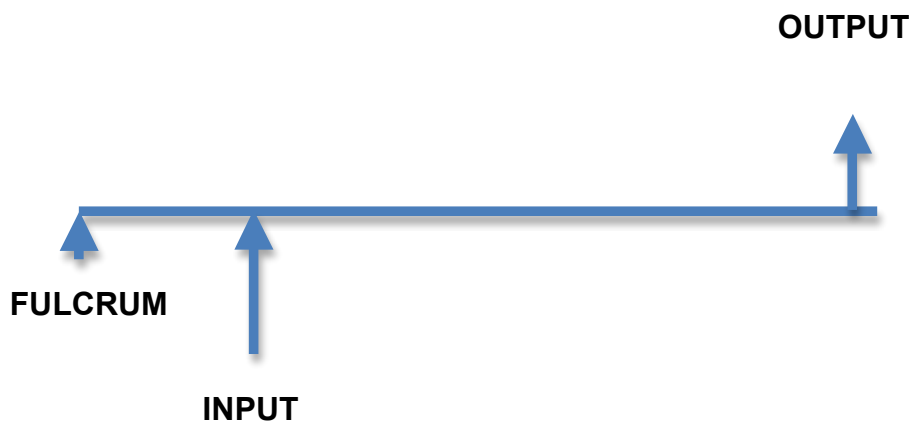
16. Here the fulcrum is at one end of the lever, the applied force or input is at the other end and the weight we are lifting, the OUTPUT, is in between.



17. In this case, the distance to the lifting force is greater than to weight. We are again using a smaller force to lift a bigger one and obtain a mechanical advantage.
18. One might wonder where one is likely to come across a strange device like this second class lever. One common example is a wheelbarrow. The fulcrum is the wheel. The levering force is provided by my hands at the end of the handles and the weight is in the barrow.
19. Because the barrow provides me with a mechanical advantage, I am able to carry a heavier weight in the barrow than I can lift with my unaided hands.
20. If I want to make it easier for myself and reduce the pull on my arms, I can push the weight a bit forward in the barrow. Or I can hold the handles of the barrow a bit further out. Both of these increase the mechanical advantage. One can see that knowing a little bit about second class levers is quite useful in a garden or on a building site.
21. It also shows us that one needs to be fairly cautious when shifting heavy weights around in a wheelbarrow. Just because it is easy to wheel it around does not mean that you will not injure your back if you try to lift it out of the barrow.
22. We can also join two second class levers together to make a nutcracker. In this case, the hinge is the fulcrum. We apply the force at the end of the handle and the greater force is applied at the nut.
23. In this case, you will see that there are two positions for the nut. The one further from the fulcrum applies a lower force when we squeeze on the end but allows us a bigger movement

and so we can crack a bigger nut. The small notch closer to the fulcrum gives us a bigger force but a smaller range of movement.

24. I am sure lots of people will be fascinated when you are at a party and can explain to them that the nutcracker they are using is actually a pair of second class levers. And if they are trying unsuccessfully to crack a nut in the big notch, you will be able to explain to them that they can increase their mechanical advantage by moving their hand further out along the handle or by using the smaller notch – or both.
25. We can now look at yet another kind of lever which is similar to the second class lever and is called a **Third class lever**. The fulcrum is at the end but the applied force is here and the resulting force is further away.



26. In other words we apply a large force at a short distance from the fulcrum to produce a smaller force further away. The mechanical advantage is less than one. There is in fact a mechanical disadvantage.
27. The most familiar example of a third class lever is when we used a linked pair of them as a pair of tongs. Although this type of lever does not offer us the mechanical advantage of being able to use a small force to move a big one, it does enable us to apply a force at a distance. It is useful for lifting noxious objects we do not want to touch with our fingers. A bigger version is found in the tongs we use for shifting hot coals about in the fire.
28. What may come as a surprise is that this type of lever is most commonly found in the human body. One of the clearest examples is the way the biceps brachii and the brachialis muscles work on the forearm (p102 Stone and Stone).

29. The elbow joint is the fulcrum. The muscle tendons from the upper arm insert into the bones of the lower arm – the biceps brachii into the radius and the brachialis into the ulna. These insertion points are quite close to the joint.
30. When I flex my arm to raise my hand, I am using quite a strong force here beside the joint to counter the small downward force of the weight of my hand. The arm is thus an example of mechanical disadvantage in terms of its working as a lever.
31. If you look at an anatomy book you will find lots of other examples where muscles insert close to the joint but the weight of the body part, or the force that is exerted when the muscle contracts, is further away (eg rectus femoris p170).
32. The human body at work can quite accurately be described as a beautifully, or badly, coordinated set of third class levers.
33. I would now like to spend some time talking about the various ways in which Alexander uses the phrase *position of mechanical advantage*. It can be confusing.
34. As always when I am doing something like this, I find the work Jean Fischer has put into editing, producing, and indexing the Mouritz editions of Alexander's books extraordinarily useful. The AT profession owes Jean an enormous debt.
35. The phrase *position of mechanical advantage* is mainly used in *Man's supreme inheritance*. Alexander just mentions it once in *Constructive conscious control of the individual* and there is no reference to it in the other two books.
36. The first time it comes up in *Man's supreme inheritance* Alexander is talking about the way the word "relaxation" as commonly used, simply means a damaging form of muscular collapse.
37. He goes on explain what relaxation should properly mean:

For relaxation really means a due tension of the parts of the muscular system intended by nature to be more or less tensed, together with a relaxation of those parts intended by nature to be more or less relaxed, a condition which is most readily secured in practice by adopting what I have called in my other writings the position of mechanical advantage.'

¹ Alexander (1910)p17

38. In a footnote to this, he refers readers forward to p118 for an explanation of what he means.

39. When you get there, he says

By my system of obtaining the position of "mechanical advantage," a perfect system of natural internal massage is rendered possible, such as never before has been obtained by orthodox methods, a system which is extraordinarily beneficial in breaking up toxic accumulation; thus avoiding evils that arise from auto-intoxication.²

40. He goes on to say that

"The position of mechanical advantage, which may or may not be a normal position, is the position which gives the teacher the opportunity to bring about quickly with his own hands a co-ordinated condition in the subject."

41. In a footnote on the same page, he gives what he calls a "simple practical example of what is meant by obtaining the position of mechanical advantage." He gives a detailed description of holding a couple of books against the back of chair and while the pupil continues to give the appropriate mental orders leaning them backwards

...until the weight is taken by the back of the chair. The shoulder blades will of course be resting against the books. The position thus secured is one of a number I which I employ and which for the want of a better name I refer to as a position of 'mechanical advantage.'³

42. He goes on to say

The placing of the pupil in what would ordinarily be considered an abnormal position (of mechanical advantage) affords the teacher an opportunity to establish the mental and physical guiding principles which enable the pupil after a short time to repeat the co-ordination with the same perfection in a normal position.⁴

² Ibid. p118

³ Ibid. p118

⁴ Ibid. p119

43. *Position of mechanical advantage* is an odd phrase to use and it obviously bothered Alexander because he came back to it some years later when he was working on CCCI. He says on p112 “*Readers of MSI will remember that when I used the phrase ‘position of mechanical advantage’, I pointed out that I did so because a better one was not forthcoming*”.
44. He says this failure to find a better expression was despite the fact that “*I had called to my aid a number of scientific and literary friends.*” He goes on to say that he felt the same degree of inadequacy about other phrases he used like “*head forward and up... and widen the back...*” But he explains that “*...with a teacher present to demonstrate in person what he means by them, they serve their purpose.*”
45. So when Alexander talks of *placing someone in a position of mechanical advantage* it is his own personal shorthand for a position of the pupil which “*gives the teacher the opportunity to bring about quickly with his own hands a co-ordinated condition in the subject.*”
46. This what one might call the specialised teaching use of the phrase. It essentially means a position of the pupil which enable the teacher to work most effectively on them. But as he says, the important thing is that we as teachers know what we mean by the phrase when we use it and are able to explain it to our pupil in person.
47. If I were ever asked for an alternative expression to putting someone into a position of mechanical advantage in this sense, I would be tempted to suggest that what Alexander meant was putting the pupil into a position of convenience for the teacher. But nobody has ever asked me.
48. What causes of some further confusion is that this is not the only way in which Alexander uses the phrase. Elsewhere in *Man’s supreme inheritance* he uses it in a less specialised way.
49. In one place, where he is talking of freeing the chest rather than doing deep breathing exercises, he says:
- There is such an immediate improvement in the pose of the body and poise of the chest...that a valuable mechanical advantage is secured in the respiratory movement...⁵*

⁵ Ibid. p207

50. In another place, he says:

*If we desire to lift a weight with the least possible waste of energy, we should approach it and grasp it with relaxed muscles, assuming the position of greatest possible mechanical advantage, and then gradually exert our muscular energies until sufficient power is attained to overcome the resistance.*⁶

51. An example of that would be going into monkey to lift a weight rather than bending from the hips with stiff knees and trying to haul it up. If we go into monkey, we allow the various lever systems in our body to work as they should.

52. To sum up, Alexander uses the phrases *position of mechanical advantage* and *mechanical advantage* in ways which are peculiarly his own. As long as we understand that and know what we ourselves mean by them and are able to explain them clearly to our pupils, there is no problem in using them.

53. But I think it is important to recognise that these are not the ways in which they are understood in ordinary technical discussions. So if you are giving an engineer or a physicist a lesson and feel an urge to explain monkey as a position of mechanical advantage, bear in mind that it will not make things clearer to them.

54. In fact I would tend not to use it with such people.

REFERENCES

F. M. ALEXANDER (1910) *Man's supreme inheritance* - Mouritz, London (1996 edition)

⁶ Ibid. p61