ed with stones, iron, or any heavy matter, will not overturn so easily, as when loaded with wood, hay, or any light article; for when the load is not higher than a b, fig. 22, a line from the centre of gravity will fall within the centre of the base at c; but if the load be as high as d, it will then fall outside the base of the wheels at e, consequently it will overturn. From this appears the error of those, who hastily rise in a coach or boat, when it is likely to overset, thereby throwing the centre of gravity more out of the base, and increasing their danger.

# CHAPTER II.

## ARTICLE 15.

### OF THE MECHANICAL POWERS.

Having premised and considered all that is necessary for the better understanding those machines called mechanical powers, we now proceed to treat of them. They are six in number; namely:

The Lever, the Pulley, the Wheel and Axle, the Inclined Plane, and the Screw.

These are called Mechanical Powers, because they increase our power of raising or moving heavy bodies. Although they are six in number, yet they are all governed by one simple principle, which I shall call the First General Law of Mechanical Powers; it is this, *the momentums of the power and weight are always equal, when the engine is in equilibrio.*

Momentum, here means the product of the weight of the body multiplied into the distance it moves; that is, the power multiplied into its distance moved, or into its distance from the centre of motion, or into its velocity, is equal to the weight multiplied into its distance moved, or into its distance from the centre of motion, or into its velocity; or, the power multiplied into its perpendicular descent, is equal to the weight multiplied into its perpendicular ascent.

The Second General Law of Mechanical Powers, is,

*The power of the engine, and velocity of the weight moved, are always in the inverse proportion to each other;* that is, the greater the velocity of the weight moved, the less it must be; and the less the velocity, the greater the weight may be: and that universally in all cases.

The Third General Law, is,

*Part of the original power is always lost in overcoming friction, inertia, &c., but no power can be gained by engines, when time is considered in the calculation.*

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In the theory of this science, we suppose all planes to be perfectly smooth and even, levers to have no weight, cords to be perfectly pliable, and machines to have no friction: in short, all imperfections are to be laid aside, until the theory is established, and then proper allowances are to be made for them.

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## ARTICLE 16.

### OF THE LEVER.

A bar of iron, of wood, or of any other inflexible material, one part of which is supported by a fulcrum or prop, and all other parts turn or move on that prop, as their centre of motion, is called a lever; when the lever is extended on each side of the prop, these extensions are called its arms; the velocity or motion of every part of these arms, is directly as its distance from the centre of motion, by the third law of circular motion.

With respect to the lever, when in equilibrium,—Observe the following laws:—

1. The power and weight are to each other, inversely as their distances from the prop, or centre of motion.

That is, the power P, fig. 8, Plate I. which is one multiplied into its distance B C, from the centre 12, is equal to the weight 12 multiplied into its distance A B 1; each product being 12.

2. The power is to the weight, as the distance the weight moves, is to the distance the power moves, respectively.

That is, the power multiplied into its distance moved, is equal to the weight multiplied into its distance moved.

3. The power is to the weight, as the perpendicular ascent of the weight, is to the perpendicular descent of the power.

That is, the power multiplied into its perpendicular descent, is equal to the weight multiplied into its perpendicular ascent.

4. Their velocities are as their distances from their centre of motion, by the 3d law of circular motion, p. 28.

These simple laws hold universally true, in all mechanical powers or engines; therefore it is easy (from these simple principles) to compute the power of any engine, either simple or compound; for it is only to find how much swifter the power moves than the weight, or how much farther it moves in the same time; and so much is the power (and time of producing it) increased, by the help of the engine.

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### ARTICLE 17.

#### GENERAL RULES FOR COMPUTING THE POWER OF ANY ENGINE.

1. Divide either the distance of the power from its centre of motion, by the distance of the weight from its centre of motion. Or,

2. Divide the space passed through by the power, by the space passed through by the weight, (this space may be counted either on the arch, or on the perpendicular described by each,) and the quotient will show how much the power is increased by the help of the engine; then multiply the power applied to the engine, by that quotient, and the product will be the power of the engine, whether simple or compound.

## EXAMPLES.

Let A B C, Plate I. fig. 8, represent a lever; then, to compute its power, divide the distance of the power P from its centre of motion B C 12, by the distance A B 1, of the weight W, and the quotient is 12: the power is increased 12 times by the engine; which, multiply by the power applied 1, produces 12, the power of the engine at A, or the weight W, that will balance P, and hold the engine in equilibrio. But suppose the arm A B to be continued to E, then, to find the power of the engine, divide the distance B C 12, by B E 6, and the quotient is two; which multiplied by 1, the power applied, produces 2, the power of the engine, or weight w to balance P.

Or divide the perpendicular descent C D of the power equal 6, by the perpendicular ascent E F equal 3; and the quotient 2, multiplied by the power P equal 1, produces 2, the power of the engine at E.

Or divide the velocity of the power P equal 6, by the velocity of the weight w equal 3; and the quotient 2, multiplied by the power 1, produces 2, the power of the engine at E. If the power P had been applied at 8, then it would have required to have been $1\frac{1}{2}$ to balance W, or w: because $1\frac{1}{2}$ times 8 is 12, which is the momentum of both weights W and w. If it had been applied at 6, it must have been 2; if at 4, it must have been 3; and so on for any other distance from the prop or centre of motion.

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### ARTICLE 18.

#### OF THE DIFFERENT KINDS OF LEVERS.

*There are four kinds of Levers.*

1. The most common kind, where the prop is placed between the weight and power, but generally nearest the weight, as otherwise, there would be no gain of power.

2. When the prop is at one end, the power at the other, and the weight between them.

3. When the prop is at one end, the weight at the other, and the power applied between them.

4. The bended lever, which differs only in form, but not in properties, from the others.

Those of the first and second kind, have the same properties and powers, and produce real mechanical advantage, because they increase the power; but the third kind produces a decrease of power, and is only used to increase velocity, as in clocks, watches, and mills, where the first mover is slow, and the velocity is increased by the gearing of the wheels.

The levers which nature employs in the machinery of the human frame, are of the third kind; for when we lift a weight by the hand, the muscle that exerts the force to raise the weight, is fastened at about one-tenth of the distance from the elbow to the hand, and must exert a force ten times as great as the weight raised; therefore, he that can lift 56 lbs. with his arm at a right angle at the elbow, exerts a force equal to 560 lbs. by the muscles of his arm.

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## ARTICLE 19.

### OF COMPOUND LEVERS.

Several levers may be applied to act one upon another, as 2 1 3 in fig. 9, Plate I. where No. 1 is of the first kind, No. 2 of the second, and No. 3 of the third. The power of these levers, united to act on the weight W, is found by the following rule, which will hold universally true in any number of levers united, or wheels (which operate on the same principle) acting upon one another.

## RULE.

1st. Multiply the power P, into the length of all the driving levers successively, and note the product.

2d. Then multiply all the leading levers into one another successively, and note the product.