Equilibrium

When the centre of gravity (C G) is under the point of support, the object is in stable equilibrium

When the C G is perpendicular to the point of support, the object is in unstable quilibrium.

The effect of a force (by rotation) depends on the distance to the centre of rotation.

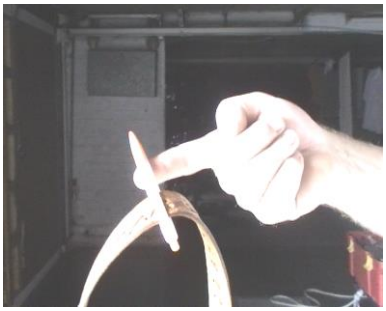
A heavy object that can rotate, falls slowlier than a light object.

A body at rest remains at rest

A body already in motion remains in motion with a constant velocity ..... (speed and direction)

Mass is a measure of inertia.

1. The finger, the ballpoint and the belt



Material:
a ballpoint with clip, a belt

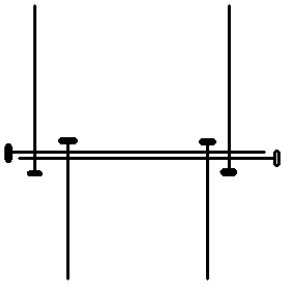
Action:
take the belt and shove the clip over the belt
-now have the ballpoint balance on one finger
-put the ballpoint over the border of the table so that the belt is hanging at the side of it

What?
Does the ballpoint fall from your finger? From the table?

Why?
No, the ballpoint won't fall.
The buckle is the heaviest point of the belt; the point of support is your finger.
When the centre of gravity (C G) is under the point of support, there is a stable equilibrium.

Application :
cycling over a wire (there is a heavy weight under the wire)

2. Nails in equilibrium



Material:
a rod, a nail which is one cm driven into the rod, another 6 nails

Action:

put the 6 nails on the top of the nail in the rod - see drawing -.
Four nails are put between the other two nails on the table.
Put the complete construction on top of the first nail.

What?
Do the nails stay in equilibrium?

Why?
The C G of the construction is under the point of support

3. Tableware in equilibrium

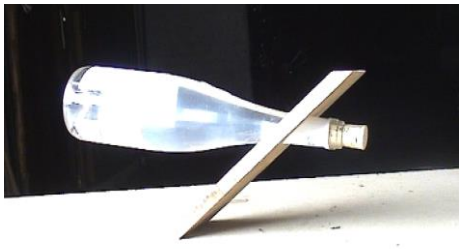
Material:
a cork,2 forks, a match, a bottle

Action:
Run the forks and the match into the cork
a) put the match on your finger
b) put the match over the border of the bottle
c) Light the match

What?
a) and b) the construction is in equilibrium
c) the match will stop burning when it has reached the border of the bottle; the construction remains in equilibrium

Why?
In any way the CG is under the point of support

4. The wine buttler



Material: an almost full bottle (closed)
a rod the bottom of which has been sawn off obliquely (45°), with

a hole (oblique in the same direction) in the upper part

Action:

put the rod obliquely on the table and shove the bottleneck through the hole
Try to keep equilibrium.

What:

Are you able to keep the bottle in equilibrium?

Why?

Yes, you are.
In this case the C G isn't under the point of support, but it is above it.
When the CG is above the point of support perpendicularly, the construction is in unstable equilibrium.

5. The slant glass

Material:

- a glass with some water
-a little fine salt or sand

Action:

piles up the salt and put the glass in it obliquely

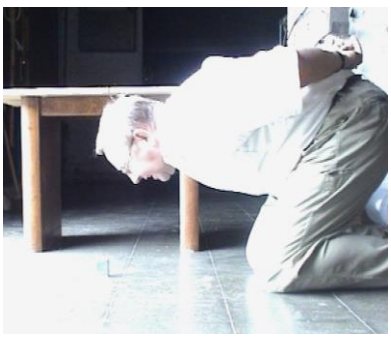
What?

Is the glass able to stand on its side?

Why?

The point in which the glass reaches the table, is the point of support. The centre of gravity is in the glass.
Even now equilibrium remains because the CG is perpendicularly above the point of support. There is unstable equilibrium.
The grains of salt may help to set up the construction, but they aren't necessary. Try to blow away the salt, not making the glass fall.

6. Equilibrium with man and woman



Material:

a man and a woman, a match box

Action:

Have both persons kneel with elbows against their knees. Put the box at the top of the fingers .Have both persons try to topple the box with their noses.

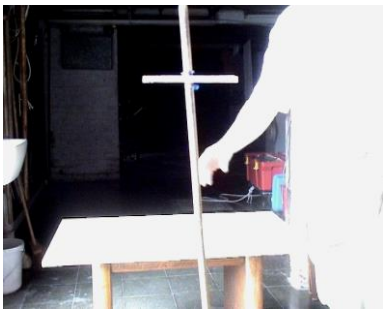
What?

Who is able to do this: the man, the woman or both?

Why?

You remember. Because the centre of gravity is positioned lower in the body of a woman, it does not move outside the base of support (past knees) as she bends with hands clasped behind her back.
A man has heavier shoulders and a woman has heavier hips.
That's why women are able to do this experiment while men aren't.

7. Playing at the (broom)stick



Material:

a long stick attached to a weight- or a broom

Action:

Try to hold the stick vertically on your finger
a)with the weight at the top
b)with the weight at the bottom

What?

Are you able to keep the stick in equilibrium?
Which way is easier?

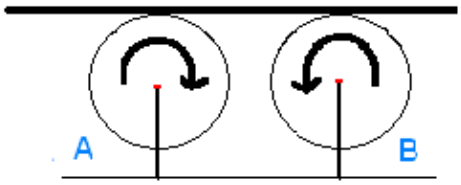
Why?

The farther the centre of mass from the point of rotation, the slower the rotation.
When the weight is at the top, you have more time to restore the balance.

Alternative

Take two pipes of the same length.
One pipe has a weight at the end, the second one has the weight in the middle.
Place both tubes vertically on the floor and make them turn over.
Which pipe will start first?
Which pipe will be on the floor first?

8. Rotating wheels



Material:

see picture

Two wheels of a size (e.g. from a bicycle) assembled next to each other, being able to rotate.

Action:

a) turn the wheels in the opposite direction (to each other)

b) repeat the action turning the other way round

What?

In which direction will the pipe move?

a) the pipe alternatively moves to the right and to the left

b) the pipe falls down to one side

Why?

a) The pipe is not exactly in the middle, which generates a larger friction on one wheel .This wheel makes the pipe move.
Because of this the friction on the other wheel gets larger, so this wheel now generates motion.

b) the larger friction remains on the same wheel- so this wheel makes the pipe fall

9. Game of equilibrium

Material:

a bottle (filled with sand); a round, flat plate; some small unbreakable objects to put on the plate and a small ball to be put on the bottleneck

Action:

-put the ball on the bottleneck

-distribute the objects on the plate and put it on the bottle in equilibrium

-now carefully take the objects from the plate one by one-try not to make the plate fall down

What?

Does the plate immediately lose its balance or does it depend on the object you take away?

Why?

A heavy object far from the middle of the plate has most impact on the balance.
As to keep equilibrium, you have to take away the lightest object nearest the middle.
You may compare the plate with a seesaw. It is in equilibrium when :

weight x weight-arm = force x force-arm

10. The obstinate vase

Material:

see box or:
-a ping-pongball cut into 2 halves; fill one half with clay; bore a hole in the other half and put in a straw. Stick both halves to each other again.
-a small nail fitting in the straw

Action

a) try to put the ball on the table with the straw vertically
b) repeat this, but with the straw resting on the table
c) repeat b) with the nail in the straw

What?

a)success
b) no success
c)success

Why?

The centre of gravity (with clay) is near to the point of support- in this way the ball is able to balance.
With the nail in the straw , equilibrium is unstable. When you hold the straw slanting, the ball will overturn.

11. Cleaning the table

Material:
a tablecloth, a bottle filled with water, a spoon, ..

Action:
-put the tablecloth on the table- make it hang down
-put the other objects on the table
-draw the cloth from the table with a quick jerk, make sure you pull the cloth downward

What?
Does the tableware fall down, or does it remain upright?

Why?
If you really give a quick jerk downward, the objects remain up right.
This phenomenon is called "inertia"
A body at rest remains at rest.

Application:
When you are standing in a starting train, you are inclined to fall backward

12. Fast, faster, the fastest

Material:
a coin

Action:
Fold your elbow so that your hand is near your ear and your fore-arm is horizontal. Put the coin on your fore-arm near to your elbow. Keep your free hand on your back. Now try to take the coin with the first hand.

What?
Are you able to take the coin?

Why?
After a few trials you must succeed.
Reason: a body at rest remains at rest.
The coin "hesitates" before falling down.

13. The lazy water-level

Material:
a water-level

Action:
Put the water-level on the table; the bubble is in the middle.
Shove the water-level to the right, fast

What?
What will happen with the bubble: will it remain in the middle or has inertia an influence?

Why?
Indeed, the bubble isn't left behind, but the water is
– because the water has a larger mass than the air.
So the water pushes the bubble forward.

14. Jumping and throwing

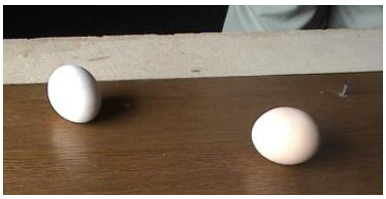
Material: a ball

Action:
a)Stand still and throw the ball about one metre right up in the air, with stretched arm. It is easy for you to catch the ball.
b) repeat the action, running.
Are you able to catch the ball now?

What?
a)Obviously
b)Where does the ball fall?

Why?
b) The ball falls back into your hand.
While you were running, the ball was in motion- it remains in motion, (with the same velocity) while being thrown up.

15. The drunken egg



Material:

2 eggs of a size , one boiled, the other one raw

Action:-

put both eggs on the table and have them rotate in giving them a short turn
-put the eggs right up and have them rotate around their longer side

What?

Do both eggs rotate in the same way?
Which egg rotates more fluently?

Why?

The boiled egg rotates more fluently, because it is compact.
In the raw egg the yolk will remain at rest, and resist the rotation