Stability of a Chest Drawers

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This example aims to demonstrate equilibrium, stability and centre of mass using an everyday chest of drawers.

Definition:
Centre of Mass: point representing the mean position of the matter in a body.[1]

This example, the chest of drawers, applies in everyday life. This particular set is designed to store clothes due to the overall dimensions and depths of each drawer; however the principles are the same for other sets, including, but not limited to an office filing cabinet.
Dimensions: 760mm x 1000mm x 400mm

For this experiment all drawers were empty to ensure the tests were constant and equal weight distribution maintained. In the real life situation, the drawers would contain items, giving weight and causing failure, toppling, at different drawer distances, not just when the drawers are fully open.

The diagrams below aim to show how only a certain number of drawers can be open at one time in order for the chest to be stable. In each diagram the centre of mass position is shown by the black dot, the support points are shown with blue dots, and the pivot point is shown by a green dot. The arrow indicates the vertical line of action for the objects mass. The chest is only stable when the arrow is between the supports. If the arrows position falls outside of the supports then the whole chest will topple and pivot about the closest support point. These are all clearly shown in the images below.

All drawers closed:

In figure1 the chest is fully closed and in its normal static equilibrium position. The centre of mass is positioned in the centre of the object, due to the symmetry of the drawers, and so the action arrow lies between the supports as expected.

Key:
- Centre of mass
- Support point
- Pivot point
- Line of action arrow

Figure 1

All drawers open:

Figure 2

Figure 2 shows how all the bottom drawers can be fully open, however the top drawer may only be slightly open to maintain equilibrium. The centre of mass position is still fairly central due to new cross sectional area. At this point the action arrow is still within the supports and thus the chest stable.

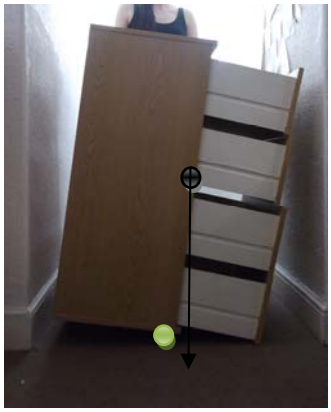

Figure 3

If the top drawer is pulled out fully at the same time as all the others, you can clearly see that the action arrow lies outside the base of the object and so now there is a pivoting point. This demonstrates that the system is no longer in equilibrium and also moves in a clockwise direction about the pivot.

(In order to take the action picture someone else was required to provide support to the system, I have not shown the resistance to demonstrate the toppling principle.)

Two drawers open:

Figure 4

This new system shows the stability when only half the drawers are open. Here it is the bottom two. The centre of mass position is lowered in this case due to the new cross sectional area and the load distribution. This case is stable.

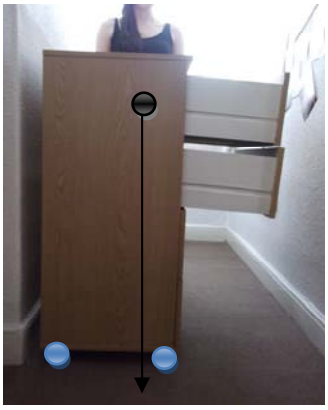

Figure 5

In this case, the top two drawers are partly open and the centre of mass position is raised but the system is still stable, however the action arrow is very close to the support point where toppling could occur with a small change in mass.

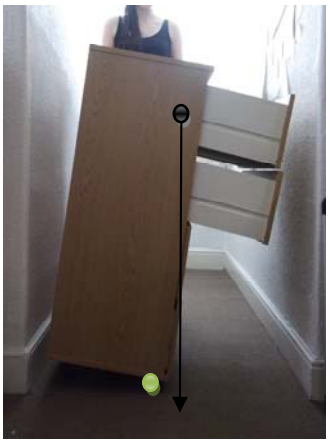

Figure 6

Here the top two drawers are now fully open and the system is no longer stable. The support is again a pivot point and shows clockwise rotation with the line of action falling outside of the base area.

Conclusion:

The conclusions which can be drawn from these demonstrations are:

- It is advised to only open one drawer at a time top guarantee stability of the chest and prevent it from toppling over and potentially injuring the user.
- If more than one drawer is left open have the bottom drawer open to increase the stability by lowering the centre of mass of the chest.
- Put heavier items in the lower drawers, and lighter items in the upper drawers.

References:

1 - wordnetweb.princeton.edu/perl/webwn , date accessed: 14/02/2013