For any given aircraft loading configuration we can determine the total moment of the loaded aircraft:

$$Total\ Moment = w_1 d_1 + w_2 d_2 + w_3 d_3 + w_4 d_4 + \ldots \quad (1)$$

Where w is the weight of each individual item and d is its respective distance from the datum.

We also know that:

$$Total\ Moment = Total\ Weight \times Final\ Arm = W \times Arm \quad (2)$$

Where W is the total weight of the aircraft and all of the load components.

By combining these two equations, we can see that:

$$W \times Arm = w_1 d_1 + w_2 d_2 + w_3 d_3 + w_4 d_4 + \ldots \quad (3)$$

Or, written a different way:

$$Arm = \frac{w_1 d_1 + w_2 d_2 + w_3 d_3 + w_4 d_4 + \ldots}{W} \quad (4)$$

Let's jump ahead to a NEW situation, where we moved one of the items to a different location in the aircraft. In this case, the total weight will remain unchanged (since we simply relocated the item – we'll assume item 1 was the one that was moved). All of the other items remained in their original locations. The arm to the new centre of gravity for this condition could be found using the following:

$$Arm_{new} = \frac{w_1 d_{1_{new}} + w_2 d_2 + w_3 d_3 + w_4 d_4 + \ldots}{W} \quad (5)$$

Let's now define a couple of the terms that are routinely used in the weight shift equation. The first term is the change in the overall aircraft centre of gravity, D.

$$D = Arm_{new} - Arm \quad (6)$$

Let's also define a term to identify the change in the arm of the item that was moved, d.

$$d = d_{1_{new}} - d_1 \quad (7)$$

Now that those two terms are defined, we can return to the equation for D and combine it with the original equations (7), (6) and (5) we find that:

$$D = Arm_{new} - Arm = \left(\frac{w_1 d_{1_{new}} + w_2 d_2 + w_3 d_3 + w_4 d_4 + \ldots}{W}\right) - \left(\frac{w_1 d_1 + w_2 d_2 + w_3 d_3 + w_4 d_4 + \ldots}{W}\right)$$

If we multiply both sides of the equation by the total weight it now becomes:

$$WD = \left(w_1 d_{1_{new}} + w_2 d_2 + w_3 d_3 + w_4 d_4 + \ldots\right) - \left(w_1 d_1 + w_2 d_2 + w_3 d_3 + w_4 d_4 + \ldots\right)$$

You should notice that the $w_2 d_2 + w_3 d_3 + w_4 d_4 + \ldots$ elements are common to both sets of parentheses and as a result of the subtraction will disappear, leaving us with:

$$WD = w_1 d_{1_{new}} - w_1 d_1$$

If we factor out the w_1 term, we are left with:

$$WD = w_1 \left(d_{1_{new}} - d_1 \right)$$

If we compare this equation with equation (7) we should recognize that the term in parentheses is simply the change in arm of the item that was moved, d. As a result, we can re-write the above equation as:

$$WD = w_1 d$$

Since the w_1 term was simply the weight of the item that was moved, we don't really need to keep the subscript so we can clean up the above equation to make it:

$$WD = wd$$

Which could also be written as:

$$\frac{w}{W} = \frac{D}{d}$$

Where:

- w is the weight of the item that was moved;
- W is the total weight of the aircraft and the entire load;
- D is the distance that the aircraft centre of gravity is moved; and
- d is the distance that the item was moved.