**r: Vector from pivot point to center of mass**

F: force on beam due to gravity

Beam center of mass

Pivot Point

**Figure 1: Balance Beam Horizontal:** $\rightharpoonaccent{r} ×\rightharpoonaccent{F}=0$. Torque is zero.

**r: Vector from pivot point to center of mass**

F: force on beam due to gravity

Beam center of mass

Pivot Point

**Figure 2 Balance Beam Tilted:** $\rightharpoonaccent{r} ×\rightharpoonaccent{F}\ne 0$ Restoring torque present.

The relevant formula:

$$\rightharpoonaccent{τ}=\rightharpoonaccent{r} ×\rightharpoonaccent{F}$$

$$ = \rightharpoonaccent{r} ×m\rightharpoonaccent{g}$$

Where (see diagrams)

$\rightharpoonaccent{F}$ = the force (a vector) acting on the beam by gravity.

$\rightharpoonaccent{r}$ = the distance (a vector) from the axis of rotation to the point at which the force acts.

$\rightharpoonaccent{τ}$ = the resulting torque (a vector) acting on the beam.

$m$ = mass of the beam

$\rightharpoonaccent{g}$ = acceleration (a vector) due to gravity.

In English:

The restoring torque on the balance beam is the cross product of the Force vector (Black arrow) and the Position vector (Red arrow). If the vectors are parallel the magnitude is zero. If they are not parallel the magnitude is non-zero. The position vector is defined as the point at which the force is applied minus the point for which torque is to be calculated.

If you want to include the pans hung from the ends of the beam, you may, but if you do it right you will find out they don’t make a difference. Their contributions cancel.

P.S.

When analyzing the contributions of the pans it is important to define the hanging point of the pans to be at the same elevation as the pivot point. Otherwise there will be non-offsetting torques contributed by the pans.