Physics with Synno – Motion-2 – Lesson 19

M.6.2 Stability

As we already know the centre of gravity of a structure is the point through which the sum of the gravitational forces acts. Therefore the centre of gravity acts as a balance point. An object will be unstable and fall over if the vertical line through its centre of gravity does not pass through its base.

Clearly the width of the base and the height of the centre of gravity affect the stability of the structure.

M.6.3 Equilibrium

An object is in Rotational Equilibrium if the following condition is met:
the net torque on the object is zero

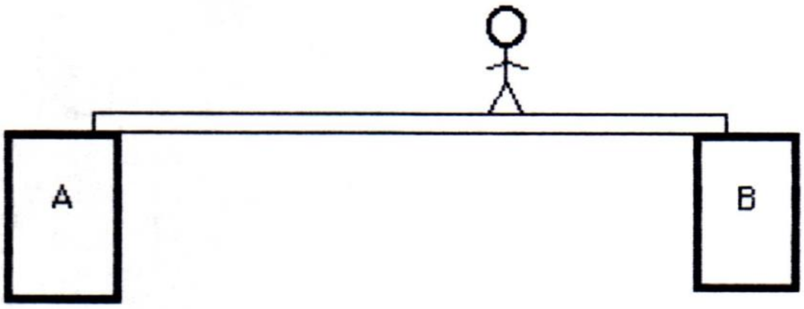
An object is in Static equilibrium if the following two conditions are met:

i) the net force on the object is zero, and
ii) the net torque on the object is zero.

Thus when a body is in equilibrium it will stay in one position unless acted upon by other forces.

Example:
A person of mass 50 Kg stands 1 m from the end of a 3 m beam. The mass of the beam is 40 Kg. Calculate the reaction at support A and support B if the system is in equilibrium.

Note: The weight of an object such as a beam acts from the centre of mass/gravity, in this case from the centre.



Take torque about A
Anti-clockwise torque = Clockwise torque

$R_b \times 3 = (500 \times 2) + (400 \times 1.5)$

$R_b \times 3 = 1000 + 600$

$R_b \times 3 = 1600$

$R_b = 533.3$ N

Take torque about B
Clockwise torque = Anti-clockwise torque

$R_a \times 3 = (500 \times 1) + (400 \times 1.5)$

$R_a \times 3 = 500 + 600$

$R_a \times 3 = 1100$

$R_a = 366.7$ N

Example

Figure 5 shows the reinforced concrete beam, XZ, of a tourist lookout. The mass of the beam is 4 000 kg.
The beam rests (with no fixed connection) on two pillars at X and Y.

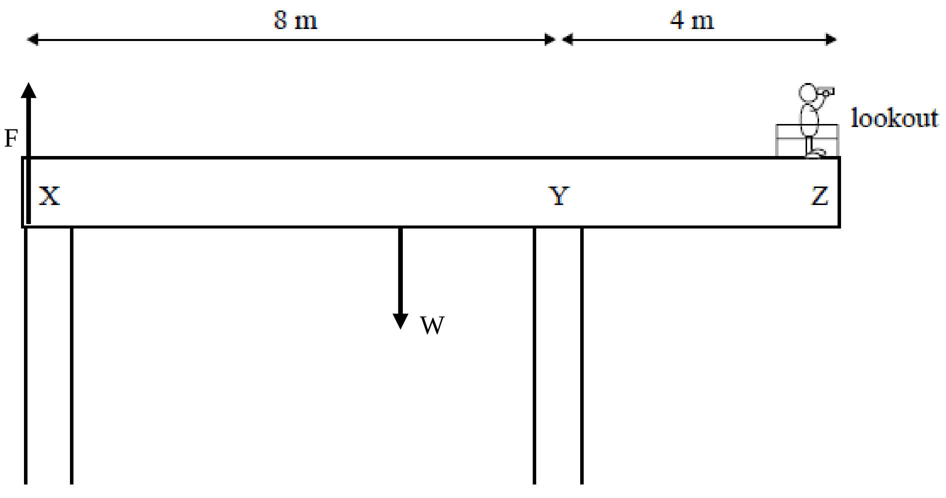


Figure 5

a With no-one standing on the lookout, what is the force of the beam on the support at X?

b What is the maximum load that can be placed at point Z (assume load concentrated at end) without the beam tilting?

Solution

a Take torque about Y

clockwise torque = anticlockwise torque

$F_x \times 8 = (4000 \times 9.8) \times 2$

$F_x = 9800\ N$

b Take torque about Y

clockwise torque = anticlockwise torque

$F_z \times 4 = (4000 \times 9.8) \times 2$

$F_z = 19600\ N$

Thus maximum load is

$19600 \div 9.8 = 2000\ kg$

Example

A street lamp of mass 20 kg is supported by a cable, AB, and a rigid rod, BC. Assume the mass of both the rod and wire is negligible. The rod (which you should assume is straight) is hinged at C, and makes an angle of 30° to the light pole, as shown in Figure 3.

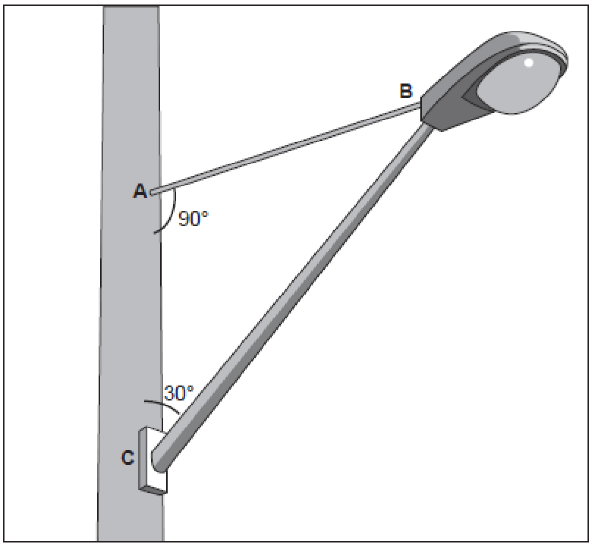
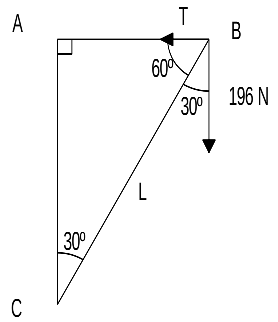


Figure 3

Calculate the magnitude of the force in the cable AB.

Solution

Let L be the length of the rod BC



Take torque about C

clockwise torque = anticlockwise torque

$L \times 196 \sin 30^\circ = L \times T \sin 60^\circ$

$T = \dfrac{196 \sin 30^\circ}{\sin 60^\circ}$

$T = 113\ N$

Problem Set #19: Text Page 405 All Questions

(FOURTH TEST AT THIS POINT)

Revision: Text Page 374 Questions 11 – 18

Text Page 407 Questions Odd Numbers