Equilibrium of Rigid Bodies

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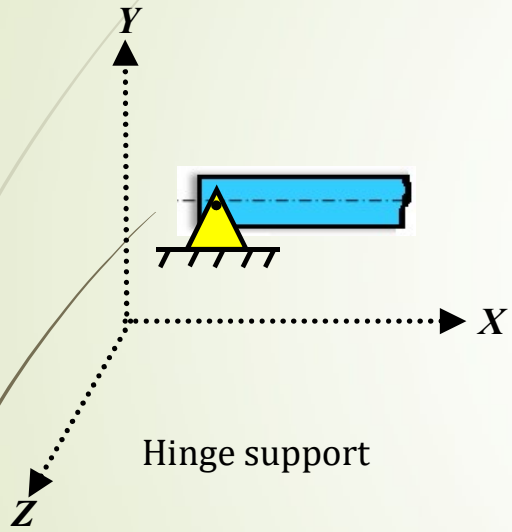
Equilibrium of Rigid Bodies

Supports

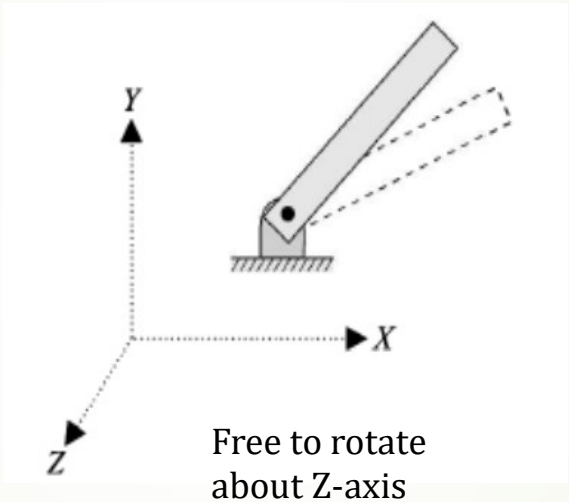
In case of rigid bodies, particularly the beams, to prevent not only translating motion but also rotational motion, these bodies are held by various supports.

Hinge Support

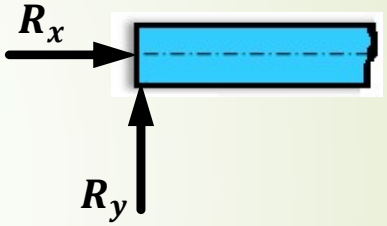
Hinge or pin-support



Hinge support



Free to rotate about Z-axis

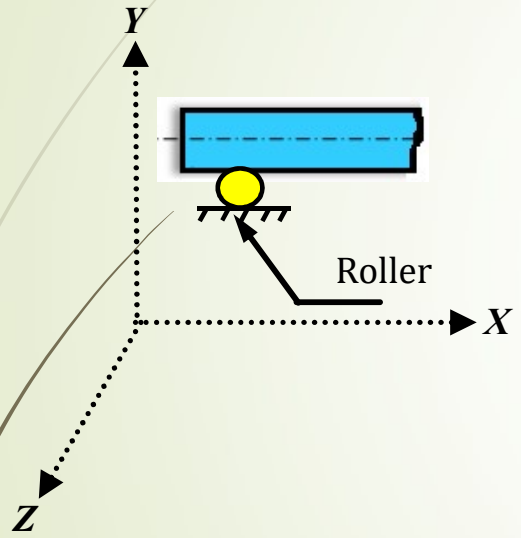


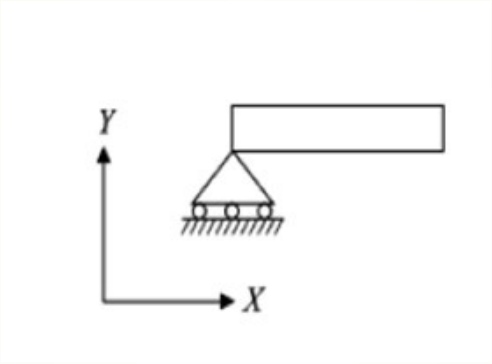
Reactions exerted by hinge support on the body

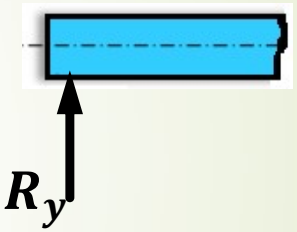
The pin support restrains the beam from translating both horizontally and vertically, but it does not prevent rotation.

Roller Support

Roller of frictionless support



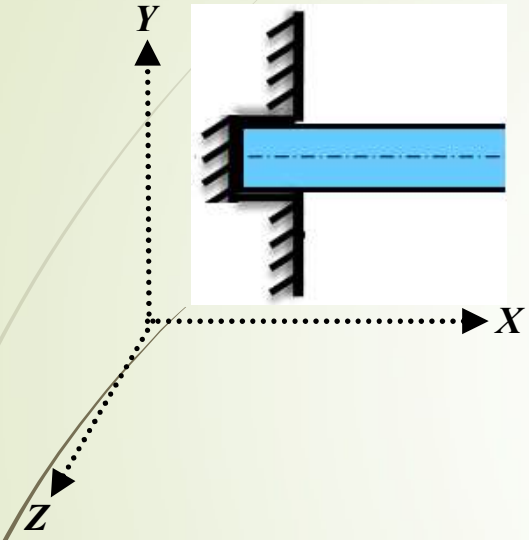


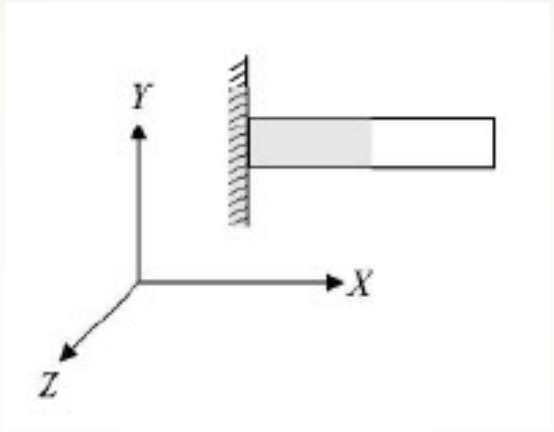


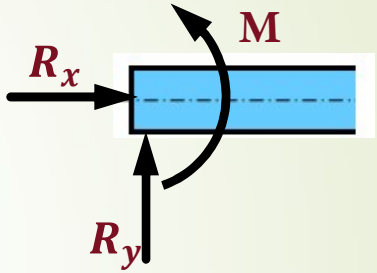
At the roller support, translation is prevented in the vertical direction but not in the horizontal direction.

Fixed or built-in support

Fixed or built-in support

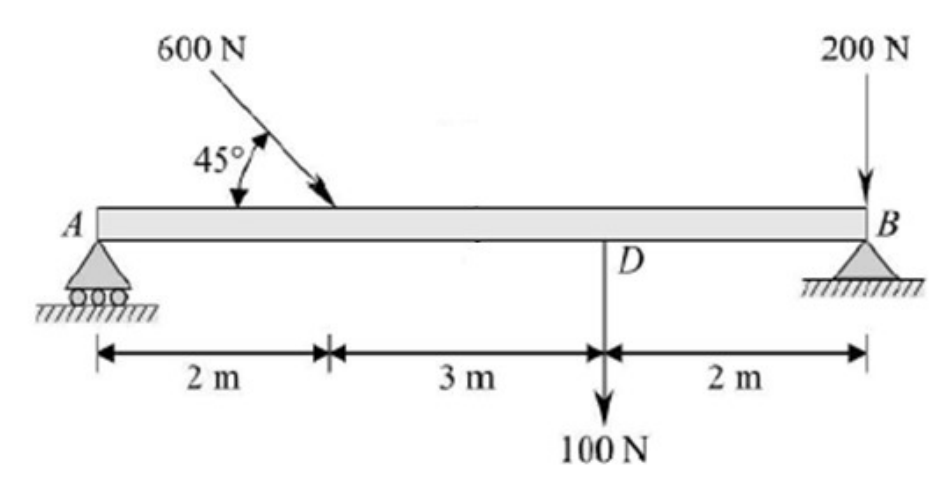






At the fixed support, both translations as well as rotation are prevented.

Problem: Determine the support reactions for the beam AB loaded and supported as shown (Neglect the weight of the beam).



Solution: Draw FBD of the beam

Applying the condition of equilibrium;

$\Sigma F_x = 0;$

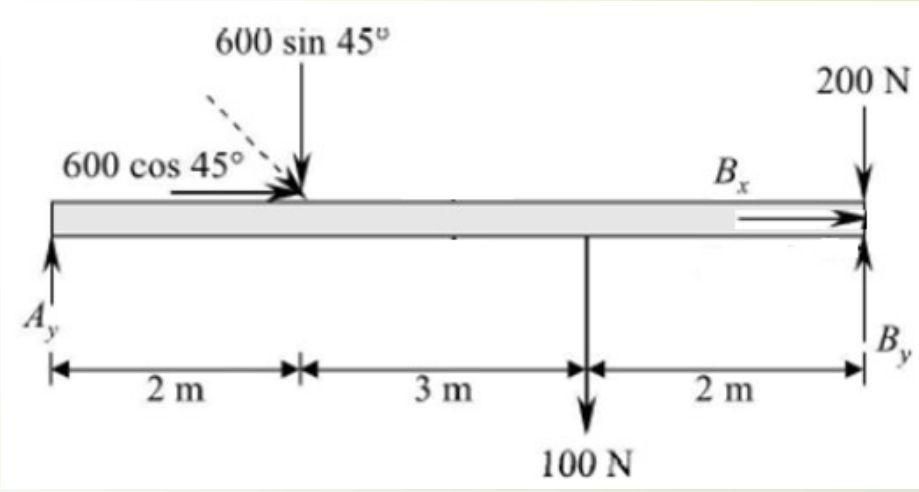
$B_x + 600\cos 45° = 0;$

$\boldsymbol{B_x = -424.26\ N;}$

$\Sigma F_y = 0;$

$A_Y + B_Y - 600\sin 45° - 100 - 200 = 0$

$A_Y + B_Y = 724.26\ N;$



Taking summation of moments about point B;

$\Sigma M_B = 0;$

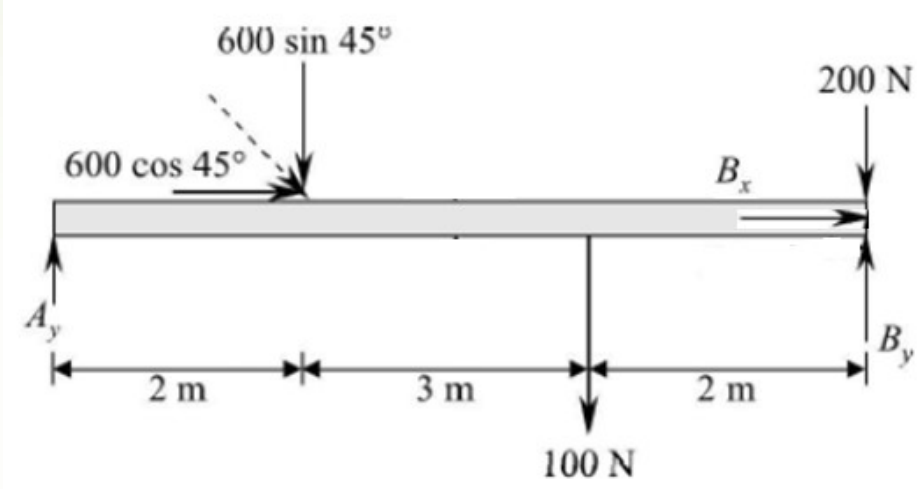
$(A_Y \times 7) - (600 \sin 45° \times 5) - (100 \times 2) = 0;$

$$\boldsymbol{A_Y = 331.62\ N}$$

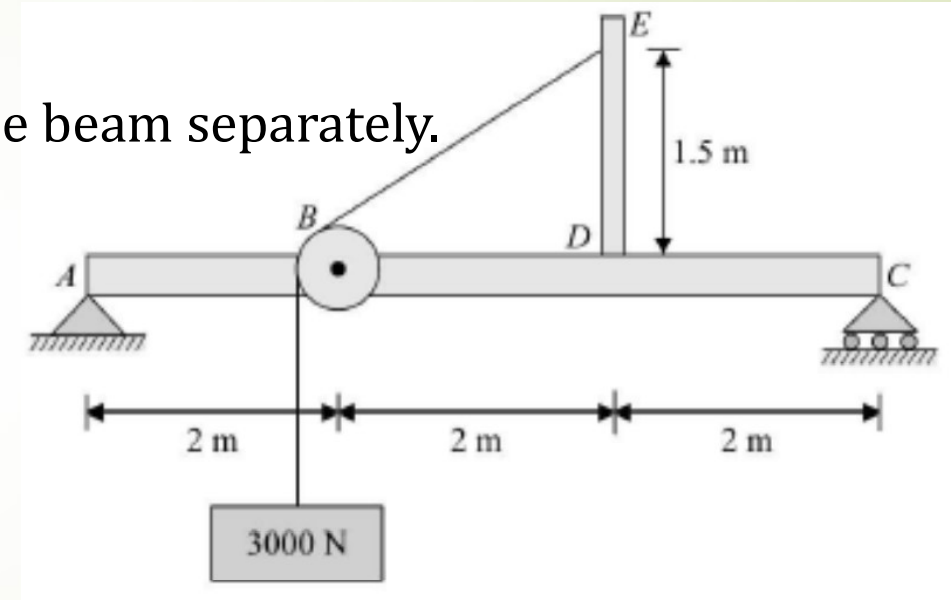
$A_Y + B_Y = 724.26\ N$

$B_Y = 724.26 - 331.62 = 392.64\ N$

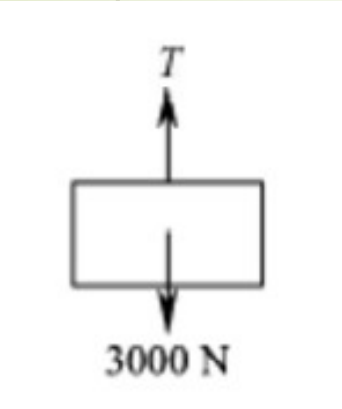
$$\boldsymbol{B_Y = 392.64\ N}$$



Problem: A smooth pulley supported a load of 3000 N is mounted at B on a horizontal beam as shown in the figure. If the beam weighs 1000 N, find the support reactions at A and C. Also find reactions at the pin supporting the pulley. (Neglect the weight and size of the pulley).



Solution: Draw FBD's for the block, pulley and the beam separately.



FBD of the block

$$\Sigma F_y = 0;$$

$$T - 3000 = 0;$$

$$\boldsymbol{T = 3000\ N};$$

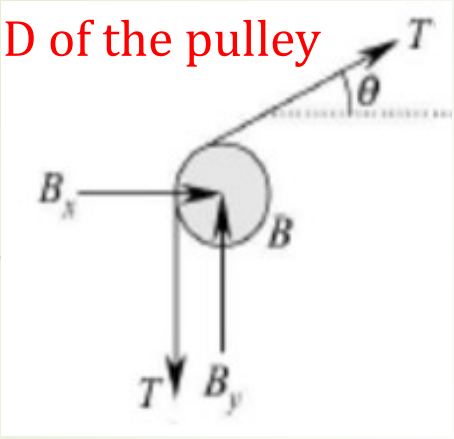
In triangle BDE

$$\tan\theta = \frac{1.5}{2} = 0.75 \rightarrow \theta = 36.87°;$$

$$\sin 36.87° = 0.6;$$

$$\cos 36.87° = 0.8;$$

FBD of the pulley



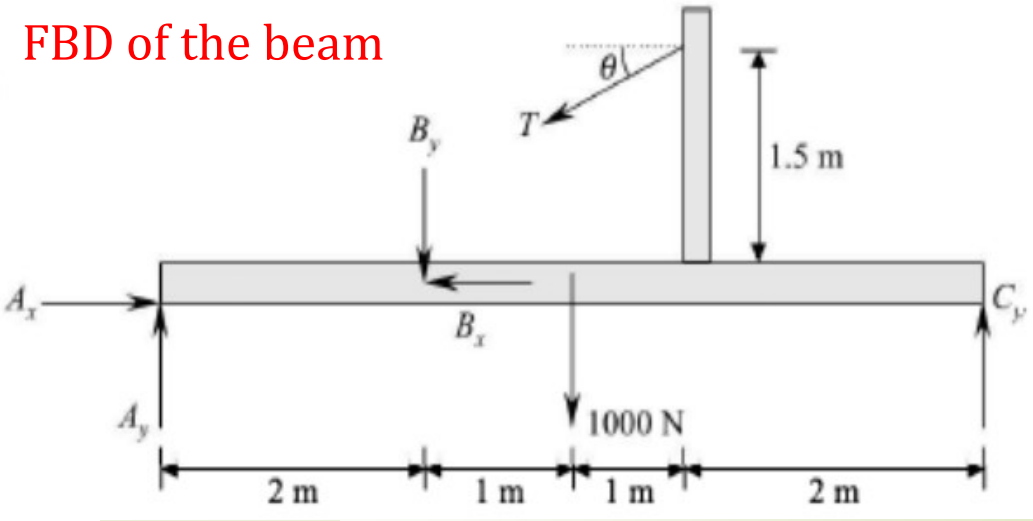
$\Sigma F_x = 0;$ $B_x + T\cos\theta = 0$

$\boldsymbol{B_x = -3000 \times 0.8 = -2400\ N};$

$\Sigma F_y = 0;$ $B_y + T\sin\theta - T = 0;$

$\boldsymbol{B_y = 3000 - 3000 \times 0.6 = 1200\ N};$

FBD of the beam



$\Sigma F_x = 0;$ $A_x - B_x - T\cos\theta = 0$

$\boldsymbol{A_x = -2400 + 3000 \times 0.8 = 0;}$

$\Sigma F_y = 0;$ $A_y - B_y - 1000 + C_y - T\sin\theta = 0$

$A_y + C_y = 1200 + 1000 + 1800 = 4000\ N$

$A_y + C_y = 4000\ N$

$\Sigma M_A = 0;$

$$(B_y \times 2) + (1000 \times 3) + (T \sin\theta \times 4) - (T \cos\theta \times 1.5) - (C_y \times 6) = 0$$

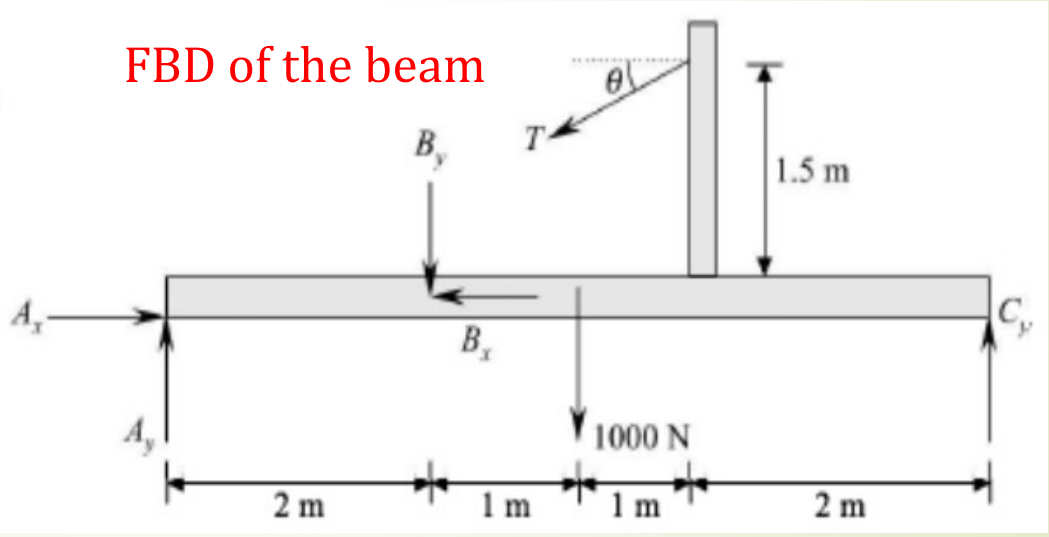
$$(C_y \times 6) = (1200 \times 2) + (1000 \times 3) + (1800 \times 4) - (2400 \times 1.5);$$

$$\boldsymbol{C_y = 1500\ N}$$

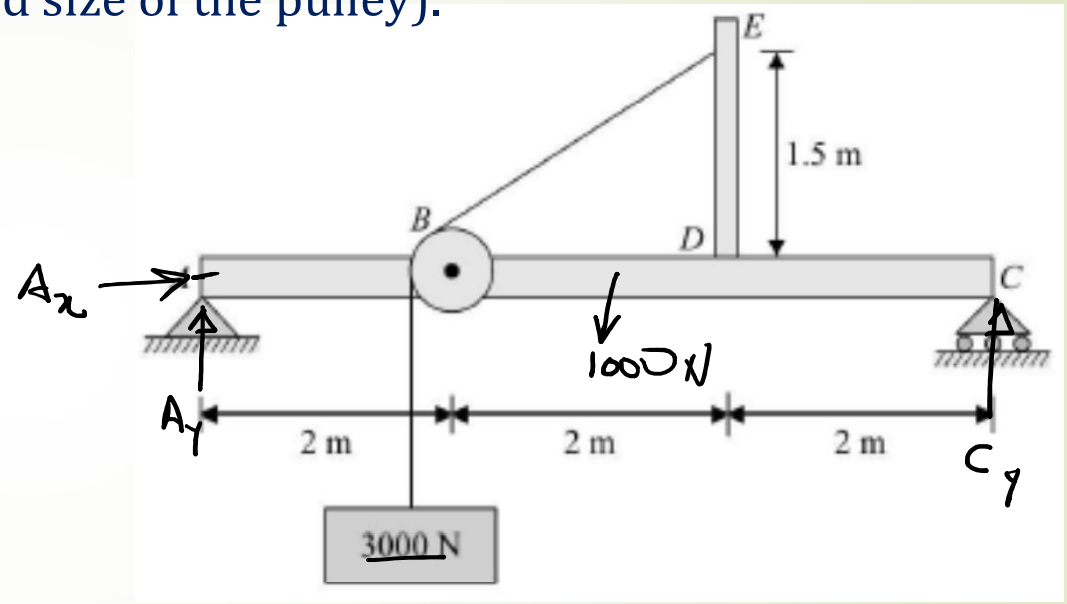
$$A_y + C_y = 4000\ N$$

$$\boldsymbol{A_y = 2500\ N}$$

FBD of the beam



Problem: A smooth pulley supported a load of 3000 N is mounted at B on a horizontal beam as shown in the figure. If the beam weighs 1000 N, find the support reactions at A and C. (Neglect the weight and size of the pulley).



$\Sigma F_x = 0$

$A_x = 0$

$\Sigma F_y = 0$

$A_y + C_y = 3000 + 1000 = 4000\ N.$

$\Sigma M_A = 0$

$(3000 \times 2) + 1000 \times 3 - C_y \times 6 = 0$

$C_y = \frac{9000}{6} = 1500\ N$

$A_y = 4000 - 1500 = 2500\ N$