A patient in the orthopedic ward must have his legs raised 2ft higher than his hips while lying flat on his bed. If the leg is 1.42m long and weighs 23kg (including plaster cast) concentrated 0.7m from his hips, what would be the tension in the horizontal rope supporting his foot, tied to the post at his bedside opposite the hips?

Solution:

$H = 2ft = 0.6096m - height\ at\ which\ the\ leg\ should\ be;$

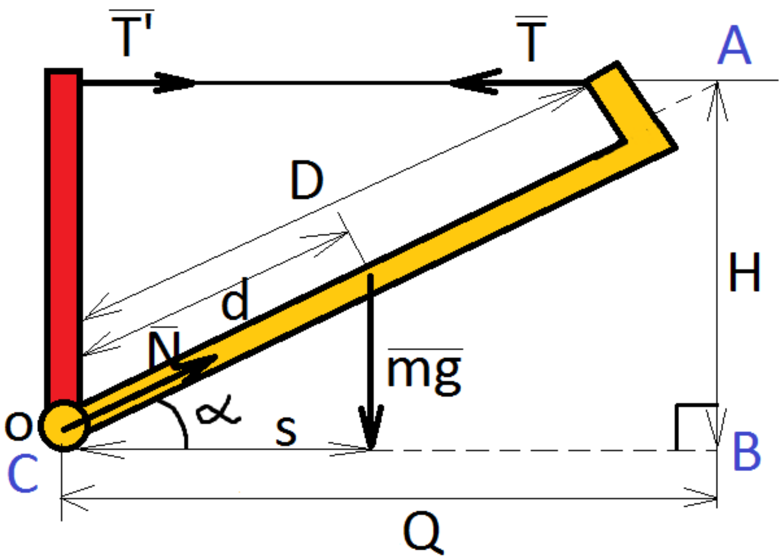
$D = 1.42m -\ leg\ length;$

$m = 23kg$ – weighs of the length including plaster cast;

$d = 0.7m -\ location\ of\ the\ center\ of\ mass.$

T – tension in the horizontal rope

$N - reaction\ force$



The second rule of equilibrium relative to the point O (rule of moments):

$$O: M_{mg} + M_T + M_N = 0\ (1)$$

$$M = F \cdot L, F - force, L - lever - arm\ distance$$

$$M_N = N \cdot L_n = M \cdot 0 = 0\ (2)\ (the\ reaction\ force\ acting\ at\ the\ point\ O)$$

$$M_T = T \cdot H\ (3)$$

$$M_{mg} = mg \cdot S\ (4)$$

$$(4) and\ (3) and (2) in (1):$$

$$mg \cdot S - T \cdot H = 0\ (minus\ sign\ due\ to\ the\ different\ directions\ of\ the\ moments)$$

$$T = \frac{mg \cdot S}{H}\ (5)$$

Now we need to find a lever-arm S:

$$right\ triangle\ \Delta ABC: Q = \sqrt{D^2 - H^2} = \sqrt{1.42m^2 - 0.6096^2} = 1.28m$$

$$(Pythagoras'\ theorem)$$

Cosine of the angle alpha for the two right-angled triangles:

$$\cos\alpha = \frac{Q}{D} = \frac{S}{d};$$

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$$S = \frac{Q \cdot d}{D}\ (6)$$

$$(6) in\ (5): T = \frac{mg \cdot \frac{Q \cdot d}{D}}{H} = \frac{mg \cdot Q \cdot d}{H \cdot D} = \frac{23kg \cdot 9.8\frac{N}{kg} \cdot 1.28m \cdot 0.7m}{0.6096m \cdot 1.42m} = 233.3N$$

Answer: tension force in the horizontal rope: $T = 233.3N$