Extra Static Equilibrium Questions - Solutions

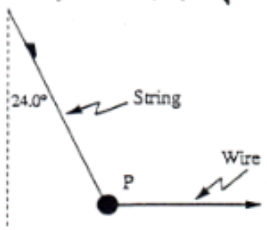
Thursday, March 10, 2011
1:55 PM

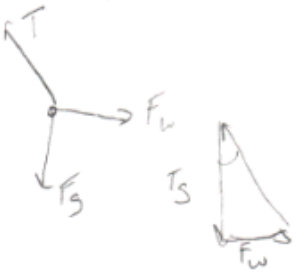
Extra Static Equilibrium Problems

KEY

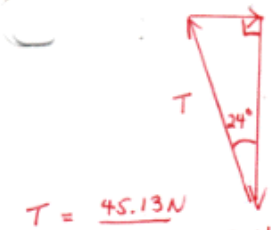
Solutions

1. A 4.60 kg mass P is held in equilibrium by a pendulum string, a horizontal wire, and gravity.





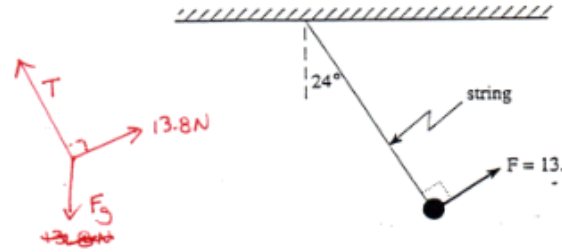
What is the tension in the pendulum string?

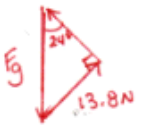


$4.60 \times 9.80 = 45.13\ N$

$T = \frac{45.13\ N}{\cos 24^\circ} = 49.4\ N$

2. A mass suspended by a string is held 24° from vertical by a force of 13.8 N as shown. Find the mass.

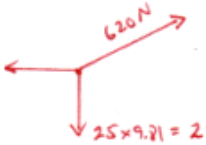


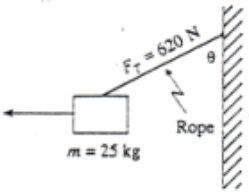


$F_g = \frac{13.8\ N}{\sin 24^\circ} = 33.92\ N$

$m = \frac{33.92}{9.81} = 3.46\ kg$

3. A 25 kg block is pulled by a horizontal force. The supporting rope can withstand a maximum tension force of 620 N.



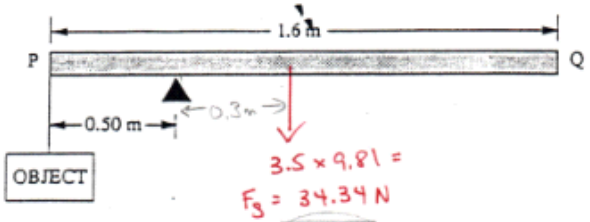


To what maximum angle, θ, can the block be pulled without the rope breaking?

$\cos\theta = \frac{245.25}{620}$

$\theta = 66.7^\circ$

4. A uniform beam has a mass of 3.5 kg. Its length is 1.6 m and a pivot is placed 0.50 m from end P, as shown in the diagram below. The beam is balanced by suspending an object at P.



What is the mass of the object?

$\tau_{cw} = \tau_{ccw}$

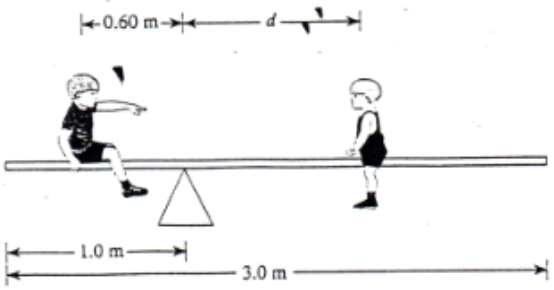
$m \times g \times 0.50 = 34.34N \times 0.30\ m$

$m = \frac{34.34 \times .30}{9.81 \times 0.50}$

$m = 2.1\ kg$

Solution $\Sigma\tau = 0 = -\tau_c + \tau_{cc}$

5. A 3.0 m uniform beam of mass 15 kg is pivoted 1.0 m from the end as shown below:



A 35 kg child sits 0.60 m from the pivot. How far, *d*, from the pivot, must a 20 kg child sit in order for the beam to be in equilibrium?

$\tau_b = \tau_d$

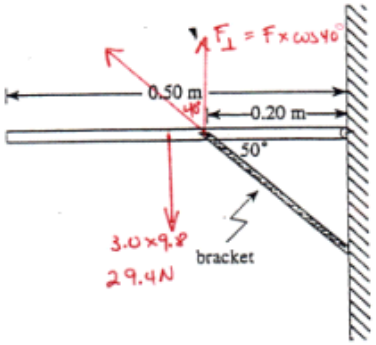
$35 \times 9.81 \times 0.60\ m = 15 \times 9.81 \times 0.5 + 20 \times 9.81 \times d$

$206.01\ N \cdot m = 73.575 + 196.2 \times d$

$\frac{206.01 - 73.575}{196.2} = d$

$d = 0.675\ m$

6. A uniform 3.0 kg shelf of width 0.50 m is supported by a bracket, as shown in the diagram below.



What force does the bracket exert on the shelf?

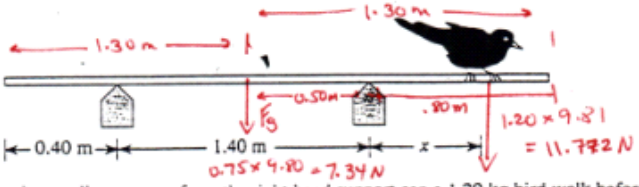
$\tau_b = \tau_d$

$F \times \cos 40° \times .20 = 29.4N \times 0.25$

$F = \frac{7.35}{\cos 40° \times 20}$

$F = 48N$

7. A 0.75 kg board of length 2.60 m initially rests on two supports as shown.



What maximum distance, *x*, from the right-hand support can a 1.20 kg bird walk before the board begins to leave the left-hand support?

$\tau_b = \tau_d$

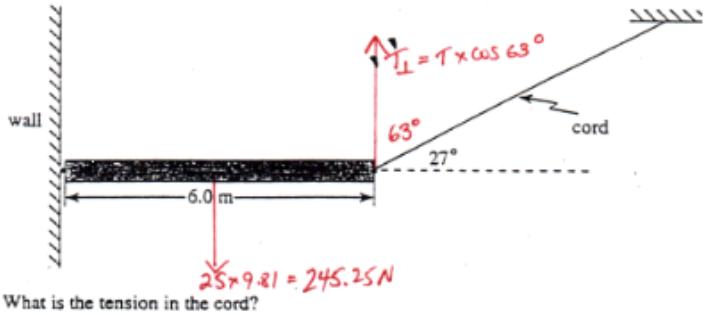
$F_g \times 0.50\ m = F_{g_b} \times x$

$7.34 \times 0.50 = 11.772 \times x$

$\frac{3.67}{11.772} = x$

$0.31\ m = x$

8. A uniform 25 kg bar, 6.0 m long, is suspended by a cord as shown.



What is the tension in the cord?

$\tau_b = \tau_d$

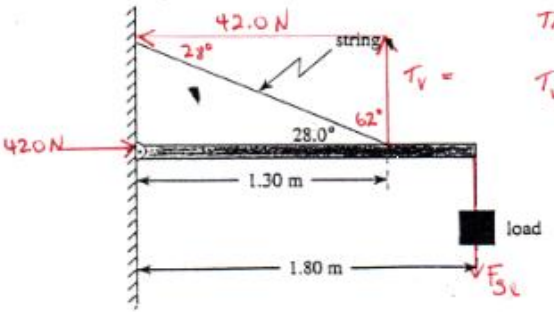
$T \times \cos 63° \times 6 = 245.25N \times 3\ m$

$T = \frac{735.75\ N \cdot m}{\cos 63° \times 6}$

$T = 270\ N$

olutions

9. The diagram shows a horizontal beam of negligible mass. The wall exerts a 42.0 N horizontal force on the lever. Find the weight of the load.



$\tau_{\downarrow} = \tau_{\curvearrowleft}$

$22.33\,N \times 1.30\,m = F_g \times 1.80$

$\frac{29.03}{1.80} = F_g$

$16.1\,N = F_g$

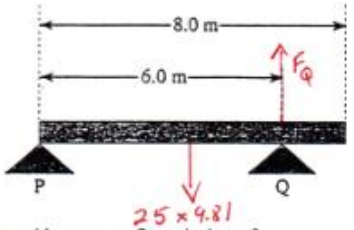
$m = \frac{16.1}{9.81} = 1.6\,kg$

$\tan 28° = \frac{T_V}{42.0}$

$T_V = 42 \times \tan 28°$

$= 22.33\,N$

10. A uniform beam of mass 25 kg rests on supports P and Q, as shown in the diagram below.



What force is exerted by support Q on the beam?

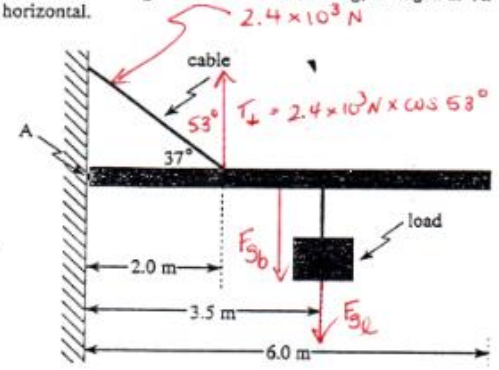
$\tau_{\downarrow} = \tau_{\curvearrowleft}$

$F_Q \times 6.0 = 25 \times 9.81 \times 4.0\,m$

$F_Q = \frac{25 \times 9.81 \times 4.0}{6.0}$

$= 164\,N$

11. A uniform beam 6.0 m long, and with a mass of 75 kg, is hinged at A. The supporting cable keeps the beam horizontal.



If the maximum tension the cable can withstand is 2.4×10^3 N, what is the maximum mass of the load?

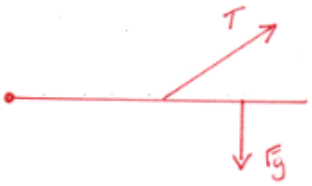
$\tau_{\downarrow} = \tau_{\curvearrowleft}$

$2.4 \times 10^3\,N \times \cos 53° \times 2.0\,m = 75 \times 9.81 \times 3.0 + mg \times 3.5$

$\frac{2888.712\,N \cdot m - 2207.25}{9.81 \times 3.5} = m$

$19.8\,kg = m$

a)



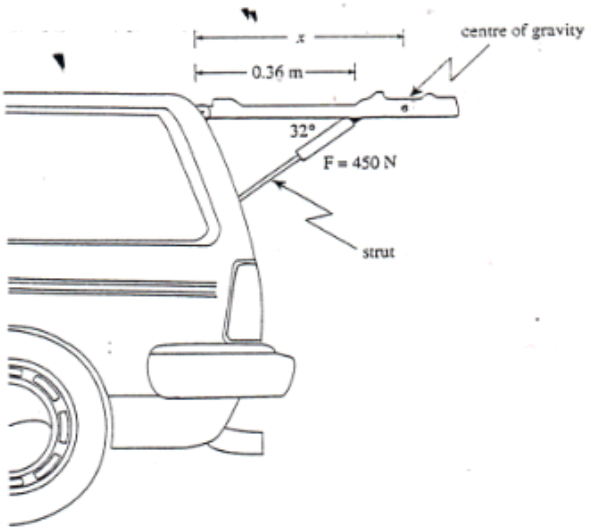
b) $\tau_g = \tau_d$

$T \times \cos 58^\circ \times 0.36 = 18 \times 9.81 \times x$

$\frac{85.8\ N \cdot m}{176.58} = x$

$0.486\ m = x$

12 The diagram shows the rear door of a station wagon supported horizontally by a strut. The mass of the door is 18 kg and the compression force in the strut is 450 N.



a) Draw and label a free body diagram showing the forces acting on the door. **(2 marks)**

b) At what distance, x, from the hinge is the centre of gravity of the door located?

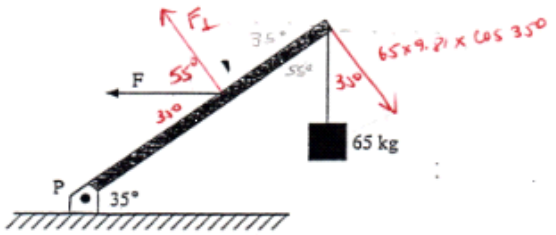
$\tau_g = \tau_d$

$F \times \cos 55^\circ \times \frac{1}{2}\ell = 65 \times 9.81 \times \cos 35^\circ \times \ell$

$F = \frac{65 \times 9.81 \times \cos 35^\circ}{\frac{1}{2} \times \cos 55^\circ}$

$F = 1820\ N$

13 A uniform beam of negligible mass, hinged at P, supports a 65 kg mass as shown in the diagram below.



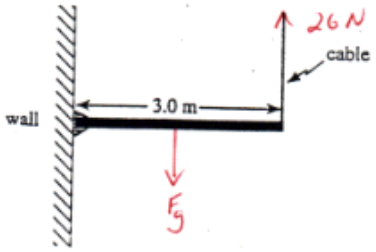
What horizontally directed force F, applied at the centre of the beam, is needed to achieve equilibrium?

$\tau_g = \tau_d$

$F_g \times 1.5 = 26\ N \times 3$

$F_g = 52\ N$

14. The diagram below shows a uniform horizontal beam hinged at the wall and supported by a vertical cable.



If the tension in the cable is 26 N what is the weight of the beam?