Chapter 4: Forces

How do I know it is a Forces question?
The question usually contains "at equilibrium", "at rest", "held" or "moves/travels horizontally/vertically at a constant speed".

Solving Problems Involving System in Equilibrium

1 Select a body or system of bodies for analysis.

2 Draw a free-body diagram showing all the forces acting on the body or system. Take care to draw the arrows for the forces starting from their correct points of action, as these will affect the moment calculation.

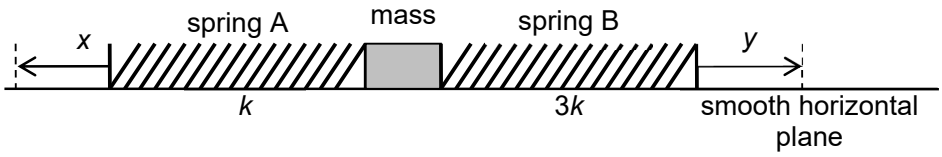
3 Select a positive direction each for forces and moments. A wise choice of the point of reference (a.k.a. the pivot) simplifies the calculation for moments tremendously.

4 Evaluate the type of problem to be solved and form the equations using:

$\boxed{\Sigma F_x = 0}$ and $\boxed{\Sigma F_y = 0}$ and $\boxed{\Sigma \tau = 0}$

Hooke's Law

1 A mass is attached to two springs as shown. The springs A and B have spring constants k and $3k$ respectively. Forces are applied to the springs such that the free end of A is displaced x to the left and that of B is displaced y to the right, but there is no change in the displacement of the mass.



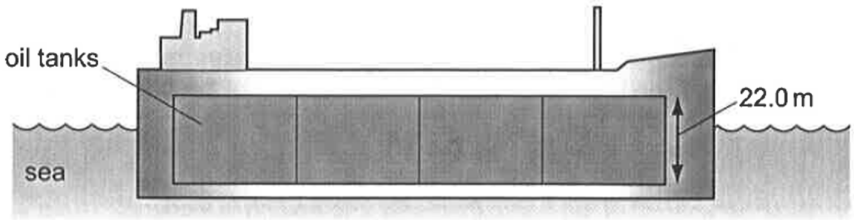
What is the value of y?

A $\frac{1}{3}x$ **B** x **C** $\frac{3}{2}x$ **D** $3x$

NYJC/09/I/8

Upthrust

2 An oil tanker, with vertical sides, has an external cross-sectional area of 36 500 m^2 in the plane of the sea.



The tanker carries oil of density 930 kg m^{-3} in its tanks, which have a constant cross-sectional area of 34 000 m^2 and depth 22.0 m. Sea water has density 1030 kg m^{-3}.

By how much does the tanker rise in the water when it unloads its oil?

A 26.2 m **B** 22.7 m **C** 21.3 m **D** 18.5 m

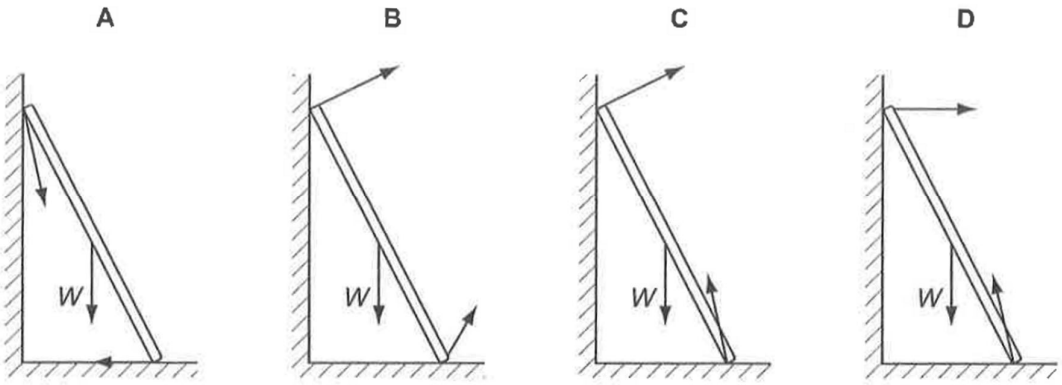
2009/I/10

Worked Example 1 (3 forces acting on a body)

A ladder of weight W rests against a vertical wall.

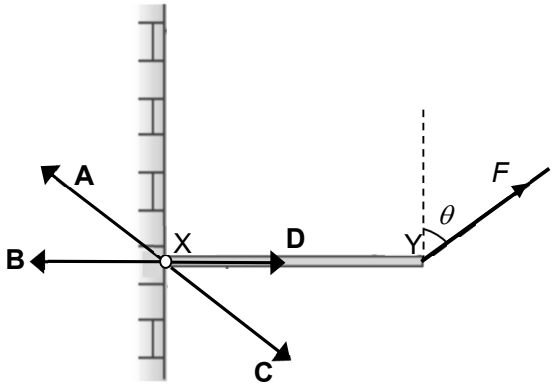
Friction between the ladder and the ground and also between the ladder and the wall prevents the ladder from slipping.

Which diagram shows the directions of the forces on the ladder?



2008/1/7

3 A uniform rod XY is freely hinged to the wall at X. It is held horizontal by a force *F* acting from Y at an angle θ to the vertical as shown in the diagram. Which arrow shows the direction of the reaction force exerted by the wall on the rod?



4 A man who weighs 600 N is sitting on a chair with his feet on the floor and arms resting on the armrests. The chair weighs 100 N. Each armrest exerts an upward force of 25.0 N on each arm and the seat exerts an upward force of 500 N.

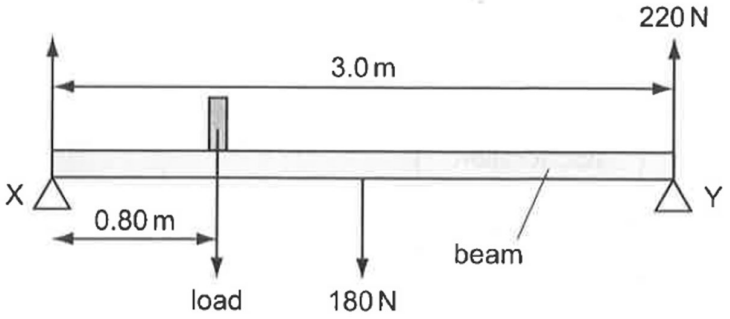
What force does the floor exert on his feet?

A 50 N **B** 75 N **C** 100 N **D** 150 N

SAJC/09/I/5

Worked Example 2 (Principle of moments)

A uniform beam in a roof structure has a weight of 180 N. It is supported in two places X and Y, a distance 3.0 m apart. A load is placed on the beam a distance of 0.80 m from X. The support provided by Y is 220 N.

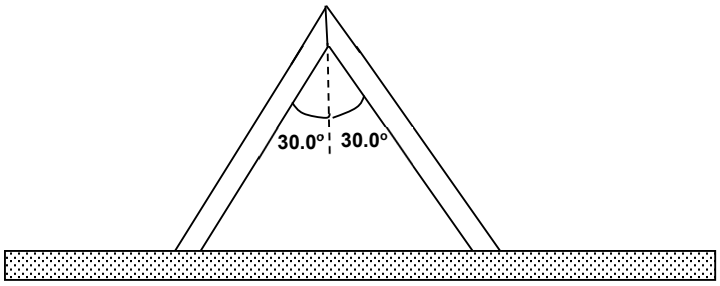


What is the value of the load?

A 270 N **B** 490 N **C** 520 N **D** 830 N

2010/I/9

5 The diagram shows an inverted "V" made of two uniform boards and each board weighs 200 N. Each side has the same length and makes a 30° angle with the vertical.



Assuming that the frictional force at the point of contact between the two boards is negligible, the magnitude of the static frictional force that acts on the lower end of each leg of the "V" is

A 58 N **B** 115 N **C** 225 N **D** 346 N

NJC/09/I/8

6 Fig. 6.1 shows two identical blocks A and B, each of mass 6.0 kg, resting on a compressed spring along a smooth slope. The spring constant for the spring is 400 N m^{-1}, and the angle of elevation of the slope is 40° above the horizontal.

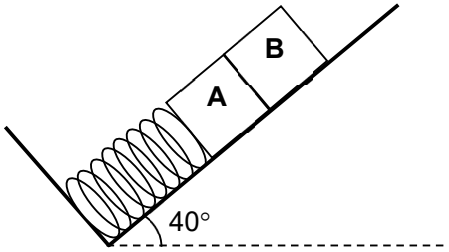


Fig. 6.1

(a) Determine the magnitude of the compressive force exerted on the spring due to the blocks. [2]

(b) Hence, determine the compression of the spring. [2]

SAJC/H1/2/2 modified

7 Fig. 7.1. shows a crane, consisting of a cab and a jib, lifting a load of girders of mass 500 kg.

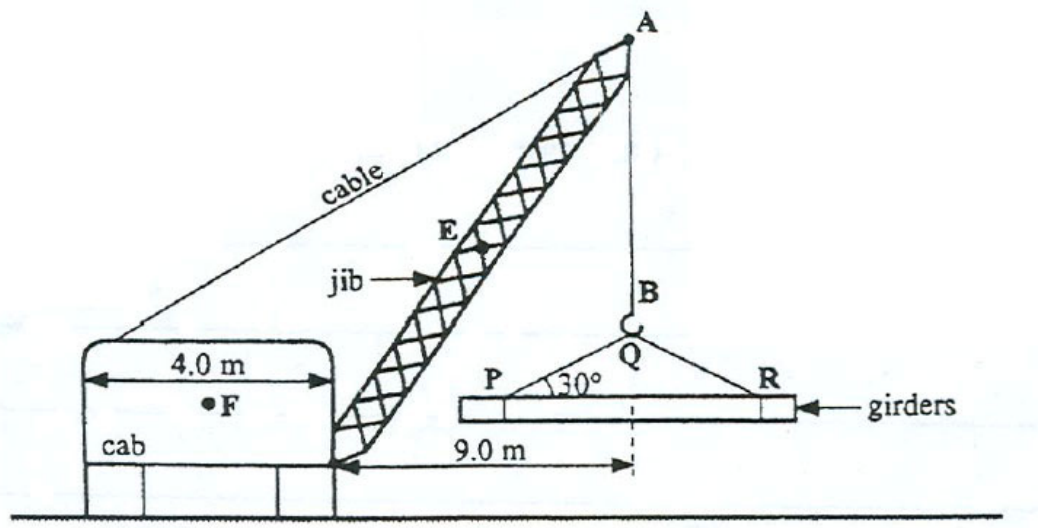


Fig. 7.1

The jib of the crane has a mass of 2500 kg, and the cab has a mass of 20 000 kg. The centres of gravity of the jib and the cab are at their mid-points E and F respectively. The hook and cable have negligible mass. Cable PBQ is a single cable and PB is at 30° to the horizontal.

(a) Calculate the tension in cable AB when the girders are lifted at a constant speed. [1]

(b) Calculate the corresponding tension in cable PQR for your answer in **(a)**. [2]

(c) Determine the maximum tension possible in cable AB that will not cause the crane to topple over. [2]

DHS/H1/2008/2/3 modified