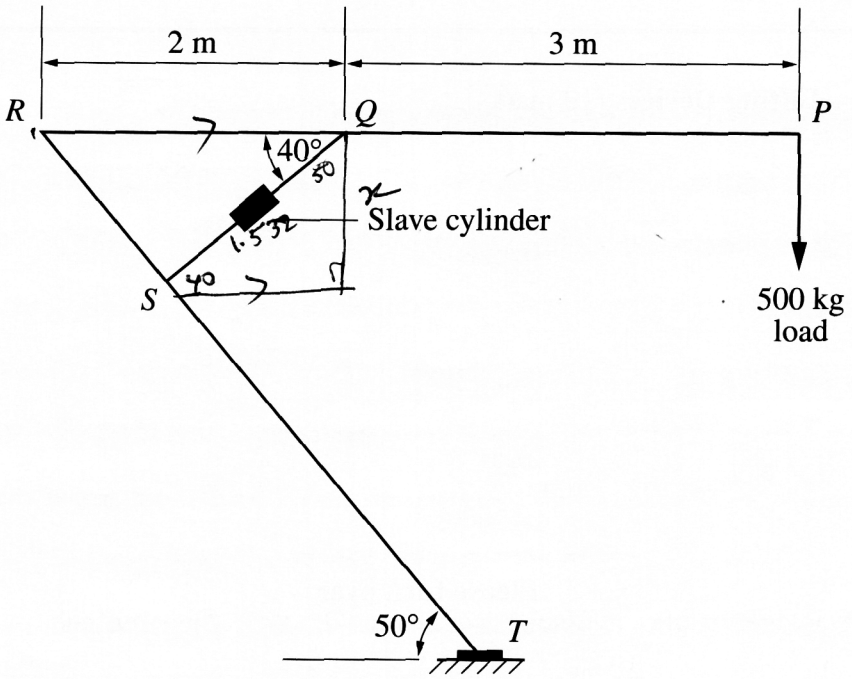
Marks

Question 14 — Lifting Devices (10 marks)

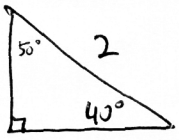
The diagram shows a lifting device. Arm *RP* is raised or lowered by a hydraulic system comprising a master cylinder and a slave cylinder.



(a) The lifting device is required to hold a load of 500 kg. Determine the minimum force required in member *QS* to keep arm *RP* horizontal. **2**

Load sets up a moment = Fd
(point R) = 500 × 9.8 × 5
= 24500 Nm

Length of QS:



$\cos 40° = \frac{QS}{2}$

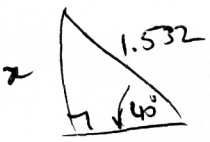
$\therefore QS = 2\cos 40$

$= 1.532\text{m}$

$M = Fd$

$24500 = F \times 0.98475$

$\therefore F = 24,879\text{N}$



$\frac{x}{\sin 40} = \frac{1.532}{\sin 90}$

$x = 1.532 \sin 40$

$= 0.98475$

Minimum force = 25 kN

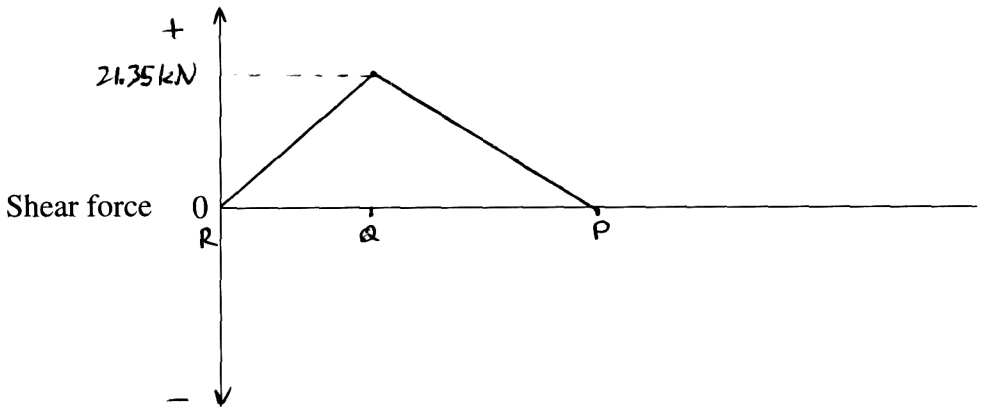
Question 14 continues on page 19

Marks

Question 14 (continued)

(b) For another set of conditions, the force in member *QS* was found to be 21.35 kN.

(i) Draw the shear-force diagram for the arm *RP*. Label the values on the diagram. The mass of the arm should not be considered. **2**



(ii) Determine the diameter of the master cylinder if the mechanical advantage of the hydraulic system is 3. The slave cylinder has a cross-sectional area of 2800 mm^2. **3**

$\frac{F_1}{A_1} = \frac{F_2}{A_2}$ MA of 3 means master cylinder area = $\frac{1}{3}$ that of slave cylinder

$\therefore$ Master cylinder $A = \frac{1}{3} \times 2800$

$= 933\frac{1}{3}\ mm^2$

$\pi r^2 = 933.33$

$r^2 = 297.09$

$r = 17.236$

$d = 2 \times 17.236$

$= 34.47mm$ (to 2 decpl)

Diameter = 34.47mm

Question 14 continues on page 20

Marks

Question 14 (continued)

(c) Gears used in lifting devices can be manufactured by powder-forming or by a variety of other processes. **3**

Identify an alternative manufacturing process, and contrast the properties of gears formed by this process with the properties of the powder-formed gears.

Gears may be FORGED. When forged, their grain structure flows along the component, making the component very strong as there are no plains of weakness. However, powder-formed gears are never as strong as forged or even cast materials for that matter. However, powder-formed materials are dimensionally accurate and do not require further machining. Forged articles, on the other hand, are not as dimensionally accurate, and for components such as gears this property is heavily desired. Gears contain regions which are hard to machine, and it is this reason that powder-forming is often preferred.

End of Question 14