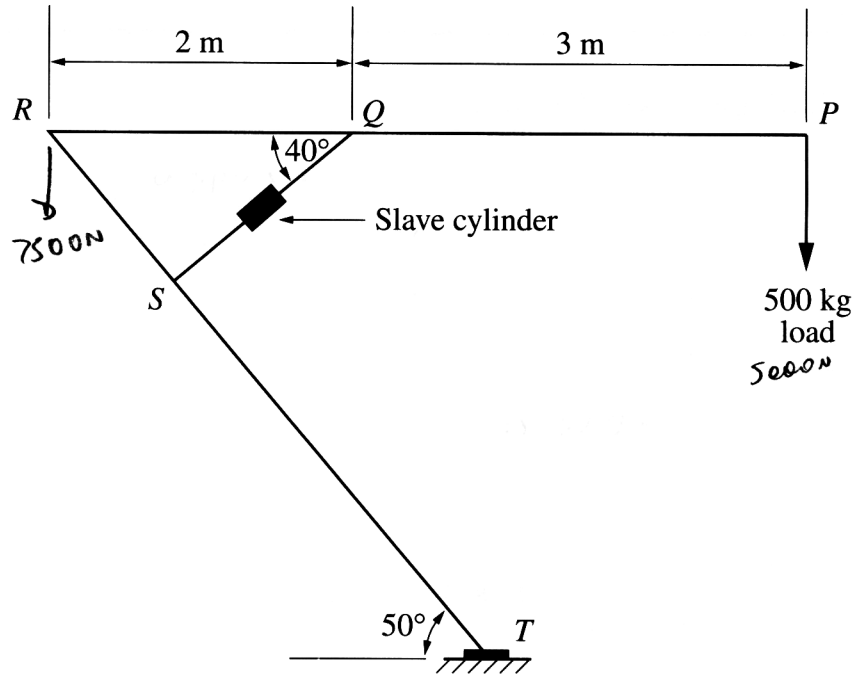## Question 14 — Lifting Devices (10 marks)

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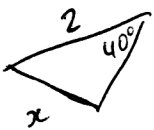

(a) The lifting device is required to hold a load of 500 kg. Determine the minimum force required in member *QS* to keep arm *RP* horizontal.

2

$$\Sigma M @ R = 0$$

$$(5000 \times 5) = 2\sin 40 \times F$$

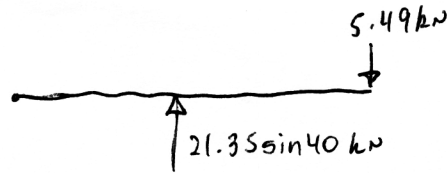$$F = 19446.55 N$$

$$= 19.45 kN$$

$$\frac{x}{2} = \sin 40$$

$$x = 2\sin 40° \ m$$

Minimum force = ...19.45kN upwards

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21.35×1000 × 2sin40 = P × S $P = 5489.41N$

$\overset{\downarrow}{5.49kN}$
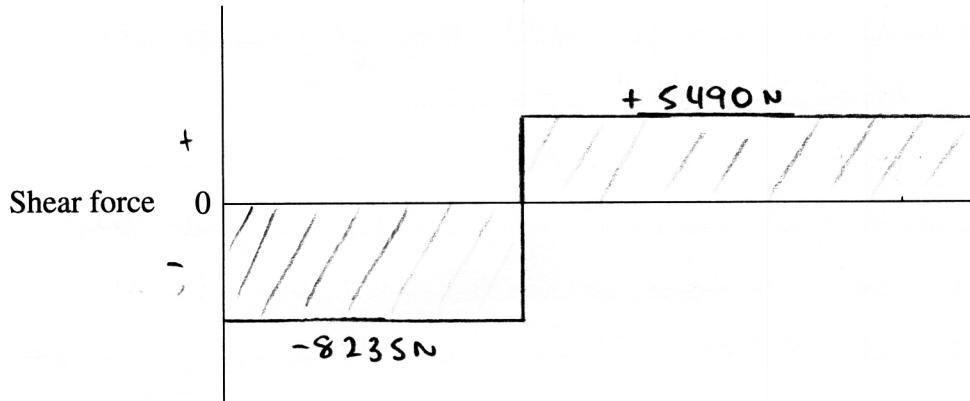
$\overset{\uparrow}{\big|}$ 21.35sin40 kN

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**

Shear force   0

+ 5490 N

−8235 N

(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**

$$\frac{F_1}{A_1} = \frac{F_2}{A_2}$$

$$A_1 = \frac{A_2 F_1}{F_2}$$

$$= \frac{2800 \times 1}{3}$$

$$= 933.33 \text{ mm}^2$$

Area = 933.33 mm^2

$\pi r^2 = 933.33$

$r = 17.24$

∴ diameter = 34.47

Diameter = ...34.47mm....

Question 14 continues on page 20

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Question 14 (continued)

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

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

Hot Forged Gears, pressing the gears to shape
with heat applied.
Forged gears will have directional grain flow
which will increase strength especially on the
gear teeth. Powder formed gears will be weaker
with specific lines of weakness evident, while the
grain boundaries in forged gears are much smaller
resulting in less slip and deformation. Powder formed
gears can be porous and hence be made self
lubricating, while forged gears are solid.
This would also, however, cause metal particles

End of Question 14

to become lodged and get stuck.
Powderformed gears will be easier and
cheaper to make.