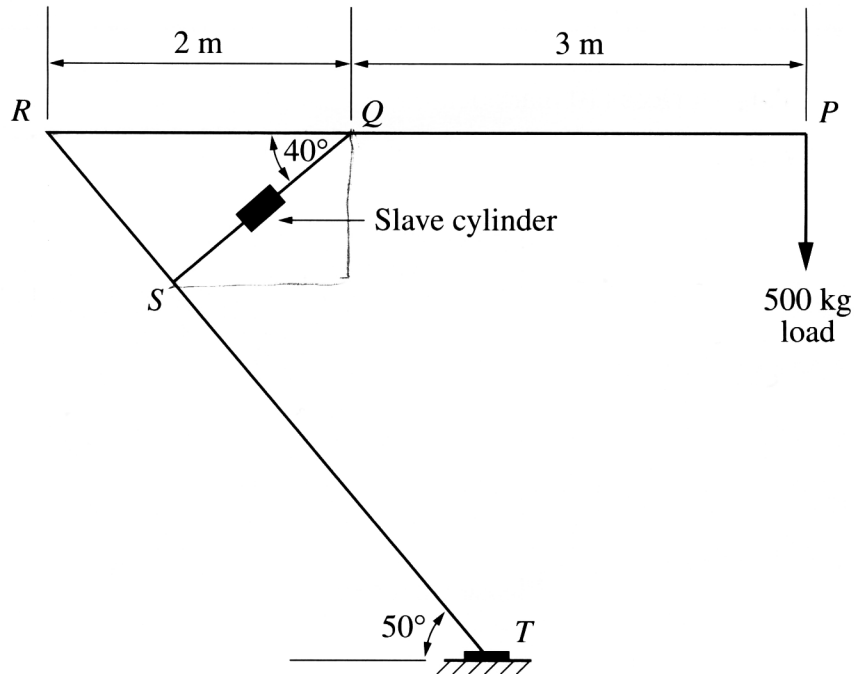**Question 14 — Lifting Devices** (10 marks)

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

$500 \times 9.8 = 4900 \, N$

$4900 \, N \times 3m = 14700 \, N$

$f = \dfrac{14700}{\cos 40}$

$f = 19189.4871S$

$\cos 40 = \dfrac{14700}{f}$

Minimum force = ...19189·5 N.. (1dp)

Question 14 continues on page 19
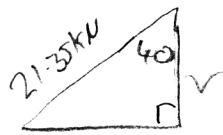
Question 14 (continued)

Handwritten at top:

$\cos 40 = \dfrac{v}{21 \cdot 35}$

$v = 21 \cdot 35 \times \cos 40$

$v = 16 \cdot 35504886 \ldots$

$\text{load} = 16 \cdot 4 \div 3$
$= 5 \cdot 5$
$(1 dp)$

(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   **2**
diagram. The mass of the arm should not be considered.

Handwritten: $f_R = -16 \cdot 4 \times 24$
$5 \times 5 \cdot 5$

Shear force diagram with labeled values: 21.6, 5.3N (upper), 0, 5.3N, 5.3 (lower)
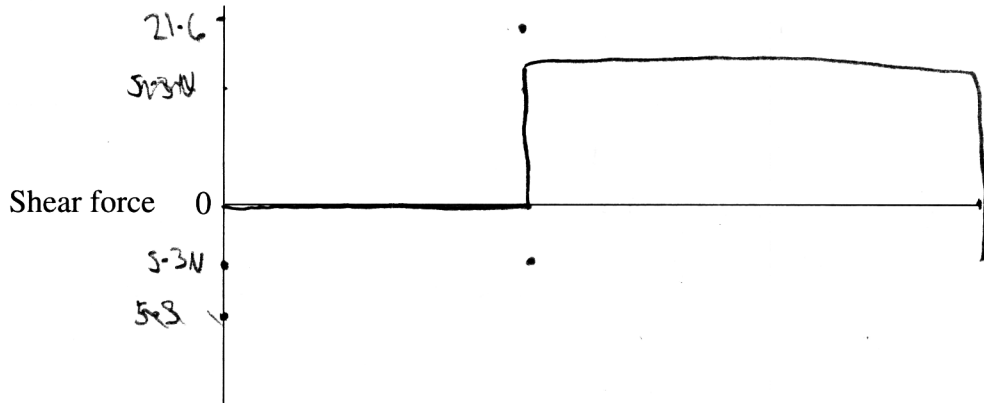
(ii) Determine the diameter of the master cylinder if the mechanical   **3**
advantage of the hydraulic system is 3. The slave cylinder has a
cross-sectional area of 2800 mm².

Handwritten working:

$P = \dfrac{F}{A}$

$\dfrac{F_1}{A_1} = \dfrac{\frac{1}{3}F_2}{3 A_2}$

$\therefore 2800 \times 3 = 8400$

$\pi r^2 = 8400$

$r^2 = \sqrt{\dfrac{8400}{\pi}}$

$r = 51 \cdot 7088294 6$

$d = 2r$
$= 51 \cdot 7 \times 2$
$= 103 \cdot 4$

Diameter = 103·4 mm (1dp)

Question 14 continues on page 20

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.

alternative process is forging, this
would be a much stronger gear, however
it would be harder & more expensive to
make. forging the gear means that
the grains will flow around the ~~gear~~ the
~~gear~~ gears creating a much stronger bond,
whilst in a powder formed gear
the grains will compressed into one another forming
a strong bond, but not as strong
as forging (see diag. below)

End of Question 14

grains flow
around gear

grains compressed
together.

forging

powder forming.