Answers all questions to **3 significant figures**.

Question 1

A ladder, leaning against a wall, makes a 60° angle with the ground. When is it more likely to slip: when a person stands on the ladder near the top or near the bottom?
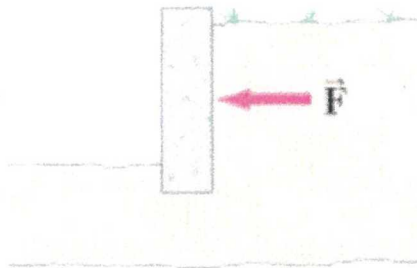Explain your answer.   **(3 marks)**
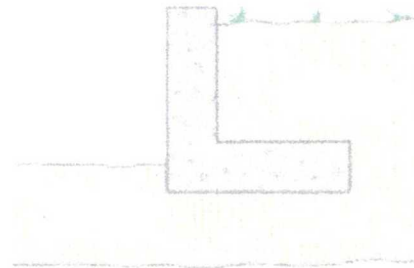
Top. ①

Further from pivot. ①

Greater torque opposing friction from ground ①

Question 2

A ground retaining wall is shown below. The ground, particularly when wet, can exert a significant force *F* on the wall.

                    (i)   **(ii)**

a) What force produces the torque to keep the wall upright?

                                                                    (1 mark)

weight force of block → Acw τ ①

b) Explain why the retaining wall in (ii) would be much less likely to overturn than in (i).

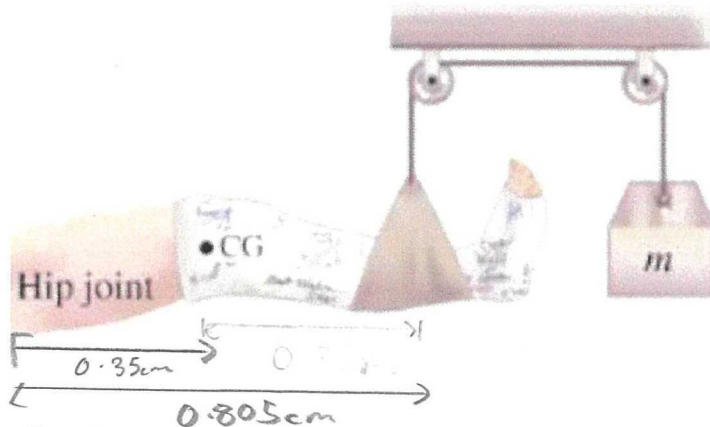   **(2 marks)**

Weight of soil on top of lower

portion ①

adds to the ACW τ ①

Question 3

Calculate the mass m needed in order to suspend the leg shown below. Assume the leg (with cast) has a mass of 15.0 kg and its centre of gravity cg is 35.0 cm from the hip joint (pivot); the sling is 80.5 cm from the hip joint (pivot).
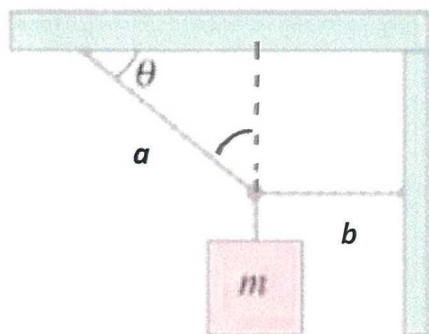

(4 marks)

$$\sum acw = \sum cw$$
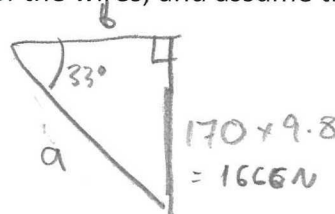
$$15 \times 9.8 \times 0.35 = m \times 9.8 \times 0.805$$

$$m = 6.52 \, kg.$$

Question 4

Calculate the tension in wires a and b. Neglect the mass of the wires, and assume that the angle θ Is 33° and the mass m is 170 kg.

(4 marks)

$$170 \times 9.8 = 1666 N$$

$$\sin 33 = \frac{1666}{h}$$

$$a = 3059$$

$$= 3.06 \times 10^3 \, N$$

$$\tan 33 = \frac{1666}{b}$$

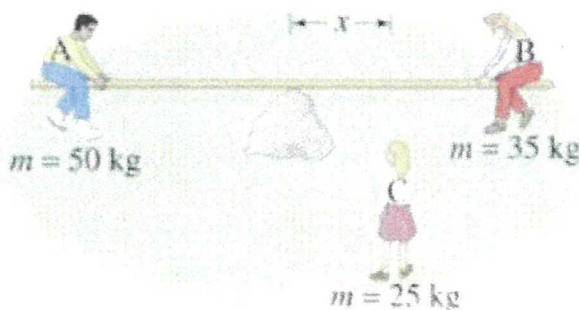$$b = 2565$$

$$= 2.57 \times 10^3 \, N$$

Question 5

Three children are trying to balance on a seesaw, which consists of a fulcrum rock, acting as a pivot at the centre, and a very light board 3.6 m long. Two playmates are already on either end. Boy A has a mass of 50 kg, and girl B has a mass of 35 kg. Where should girl C, whose mass is 25 kg, place herself in order to balance the seesaw?

$m = 50$ kg $m = 35$ kg

$m = 25$ kg

$$\frac{3.6}{2} = 1.8\,m$$

(3 marks)

$$50 \times 1.8 = (35 \times 1.8) + 25x$$
①   ①

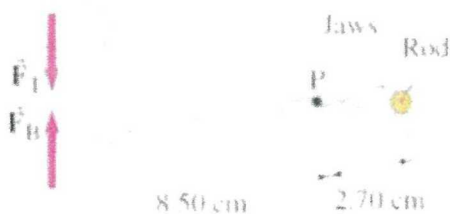$$x = 1.08\,m \quad \text{to right of rock}$$
①

Question 6

A pair of forceps are used to hold a thin plastic rod firmly. If each finger squeezes with a force: $F_T = F_B = 11.0\,N$, what force do the forceps jaws exert on the plastic rod?
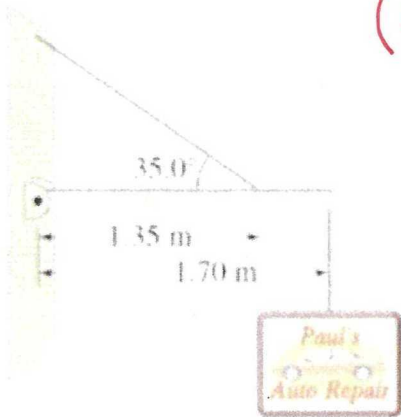

F_T

F_B

Jaws

Rod

P

8.50 cm   2.70 cm

①   ①
$$11 \times 0.085 = F \times 0.027$$

$$F = 34.6\,N$$

(3 marks)

①

Question 7

A shop sign weighing 245 N is supported by a uniform 155 N beam as shown below. Find the tension in the wire.   **(4 marks)**

$$\left(1.7 \times 245\right) + \left(\frac{1.7}{2} \times 155\right) = xc \times 1.35$$

①

$$xc = 406N$$ ①

$$\cos 55 = \frac{406}{T}$$ ①

$$T = 708N$$ ①

Question 8

A traffic light hangs from a pole as shown below. The uniform aluminium pole AB is 7.50 m long and has a mass of 12.0 kg.

Determine the tension in the horizontal, massless cable CD.   **(5 marks)** ①
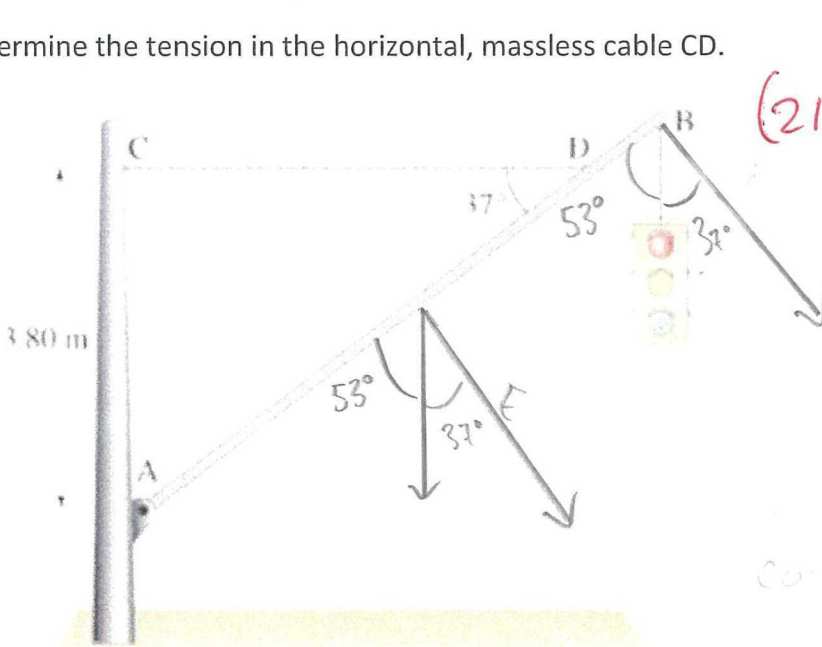
①

$$\left(211 \times 7.5 \times \sin 53\right) + \left(118 \times 3.75 \times \sin 53\right)$$

①

$$= T \times 6.314 \times \sin 37$$

①

$$T = 425N$$

①

Question 9

The diagram below shows two forces acting on a steering wheel.

a) Explain how a couple is an example of two equal forces
acting in opposite directions on the same object can create
a change in motion.   **(3 marks)**

as pivot is in the middle ①

both forces act in same direction ①

causing unbalanced force ∴ Δ motion ①
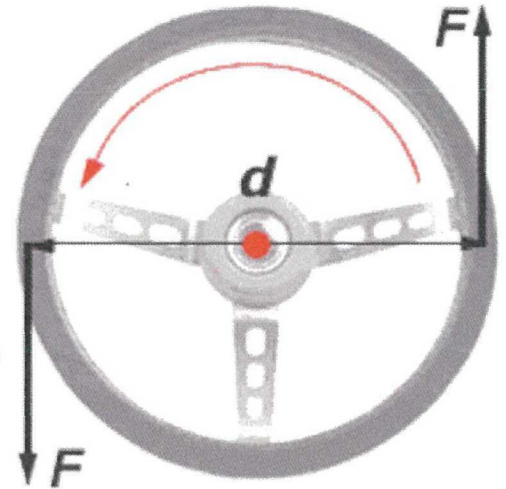
b) Calculate the total torque acting on the wheel if the diameter of the wheel *d* is equal to 25 cm and
the force *F* is equal to 2.5 N.   **(3 marks)**

$0.25 \times 2.5 = 0.625 \, N_m$

① ① ①

Question 10

An awning is cantilevered from a building as shown below. The awning has uniformly distributed mass of **15 kg**, spread over its total length of **5 m**. Calculate the mass of the sign S hanging from the awning, given that the tension in the cable C is equal to **320 N**.

(5 marks)

$$\theta = \tan^{-1}\left(\frac{1.5}{3}\right)$$

$$= 26.6°$$

①
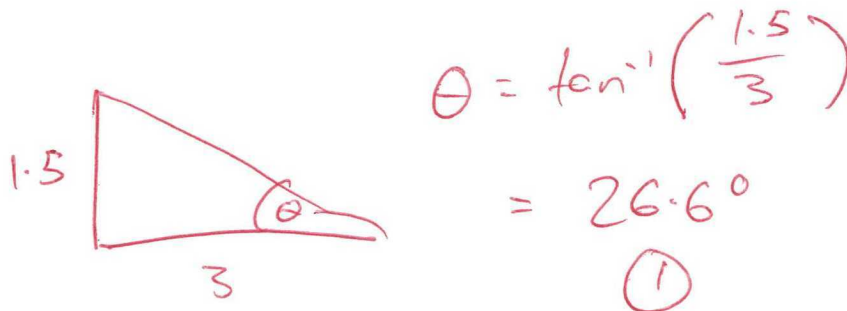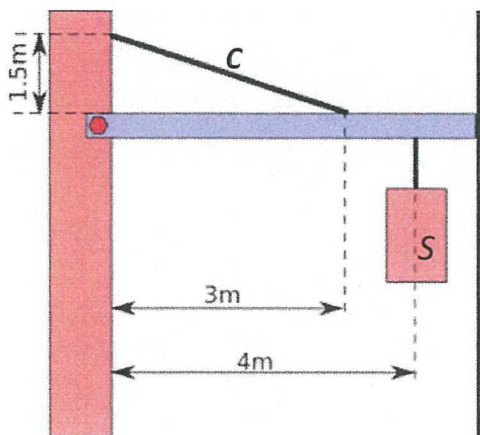
$$320 \times 3 \sin 26.6 = (15 \times 2.5 \times 9.8) + (m \times 9.8 \times 4)$$

①   ①   ①

$$m = 1.59 \text{ kg} \quad ①$$

Question 11

Jenny has a mass of 60 kg and she is standing on a 15 kg ladder as shown. There is no friction between the ladder's feet and the floor.

a) Find the reaction force from the ground on each side of the ladder.   **(5 marks)**

$\theta = \tan^{-1}\left(\frac{0.9}{2.5}\right)$

$= 21°$ ①

2.5 θ
0.9

Take moments about F_A

$(588 \times 2 \times \sin 21°) + (147 \times 0.9) = F_B \times 1.8$ ①

$F_B = 309 \, N$ ①

$\Sigma F_y = 0$

∴ $F_A + 309 = 588 + 147$ ①

∴ $F_A = 426 \, N$ ①

$\left(\text{accept } \dfrac{588 + 147}{2} = 368 \, N \text{ on each leg}\right)$

1.25 m   2.0 m   2.5 m

1.8 m

F F_A F_B

b) Find the tension in the chain between the two sides of the ladder. Assume the chain is halfway up the ladder. Hint: you will need to consider one side of the ladder as a free body.   **(5 marks)**

RH ladder as FBD

69°   21°

21° ①   69°

$\dfrac{147}{2} = 73.5 \, N$

T 73.5 N   309 N

Take moments about top:

$(T \times 1.25 \times \sin 69°) + (73.5 \times 1.25 \times \sin 21°) = 309 \times 0.9$ ① ①

∴ $T = 210 \, N$ ①

END OF TEST. PLEASE CHECK YOUR WORK CAREFULLY

$\sin 21 = \dfrac{x}{2.5}$ ①

$x = 0.9$

21°   2.5