Jack Maguire

1. **Figure 1** shows the chain and sprocket drive used on the rear wheel of the folding bicycle. Several rear sprocket sizes are provided, allowing the rider to change gear whilst riding. The smallest rear sprocket is selected for the maximum speed.

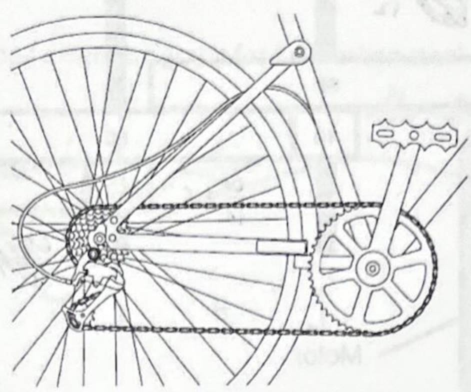


Figure 1

The bicycle data is summarised below:

Maximum required bicycle speed	7.8 ms^{-1}
Maximum comfortable pedalling rate	1.3 rev s^{-1}
Rear wheel diameter	406mm
Number of teeth on smallest rear sprocket	11 teeth

The bicycle designer needs to determine the number of teeth on the front sprocket (which is turned by the pedals) so that the bicycle can be ridden at the maximum speed.

Use the data to calculate the number of teeth needed on the front sprocket.

$C = \pi d = \pi \times 406 = 1275$

Speed = ~~7800mm / 1s~~ $7800 \div 1275 = 6.11$ revs/s

$\frac{6.11}{1.3} = 4.7$ gear ratio

$11 \times 4.7 = 51.7 = 52$ teeth

Number of teeth......52...... [4] 4

2. **Figure 2** show the plan view of the compound gearing system within a turnstile. The numbers indicate the number of teeth on each spur gear.

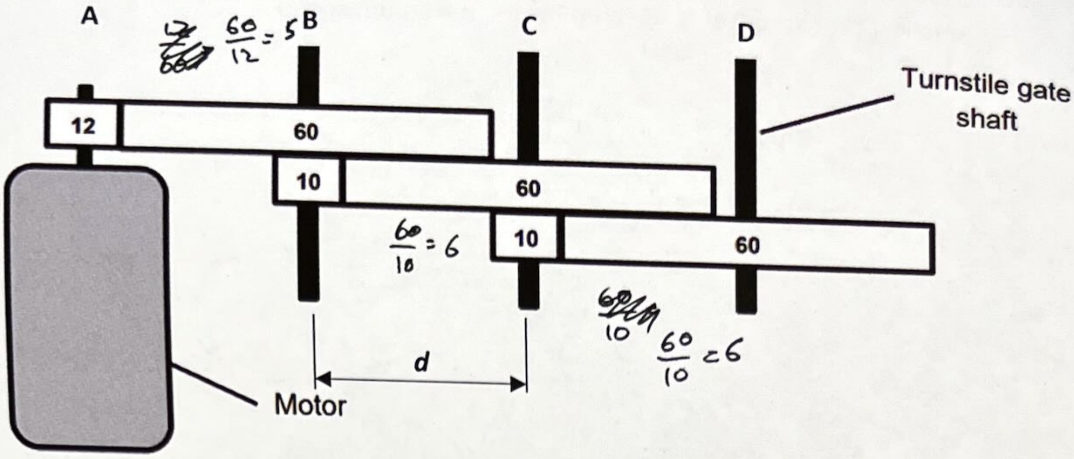


Figure 2

The turnstile gate shaft rotates through 45° during the gate opening cycle.

$45 \div 360 = \frac{1}{8}$ revs

(a) Calculate the number of revolutions turned by the motor.

$= \frac{1}{8} \times 5 \times 6 \times 6$

$= 22\frac{1}{2}$

Number of revolutions 22.5 .... [3] 3

(b) The module of each spur gear is 2.0 mm. Using the formula:

$$\textit{Module (mm)} = \frac{\textit{Pitch Circle Diameter (mm)}}{\textit{Number of Teeth}}$$

Calculate the distance **d** between the shafts **B** and **C**.

B: $2 = \frac{PCD}{10}$

PCD = 20MM

C: $2 = \frac{PCD}{60}$

PCD = 120MM

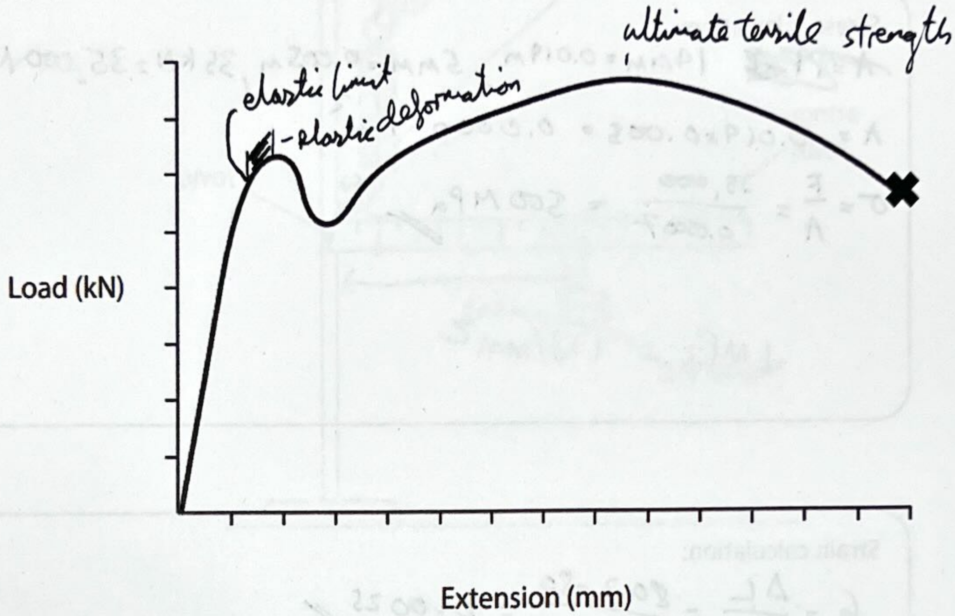
$= \frac{20}{2} + \frac{120}{2} = 70$MM

only half i.d

Shaft spacing distance 70MM .... [2] 2

3. When a design engineer investigates the suitability of a material for an engineering component, it is good practice to perform a tensile test to ensure the selected material will be fit for purpose

The graph below shows a load extension graph for low carbon steel.



Show on the graph:

a. The plastic deformation section
b. The elastic limit
c. The ultimate tensile strength

[3] 1

d. State what happens at the point marked "X".

The bar breaks

[1] 0

4. A hanging mild steel tie-bar of uniform cross-section 14 mm x 5 mm with an original length of 80 mm has a load of 35kN applied to the end. The tie-bar is measured again and found to now be 80.2 mm in length.
Find the value of tensile stress in the bar and determine the strain.

Stress calculation:

~~A=P~~ $14mm = 0.014m$, $5mm = 0.005m$, $35kN = 35{,}000N$

$A = 0.014 \times 0.005 = 0.00007\ m^2$

$\sigma = \frac{F}{A} = \frac{35{,}000}{0.00007} = 500\ MPa$

$1\ MPa = 1\ N/mm^2$

[2] 2

Strain calculation:

$\varepsilon = \frac{\Delta L}{L} = \frac{80.2 - 80}{80} = 0.0025$

[2] 2

5. **Figure 3** shows the apparatus used to investigate moments.

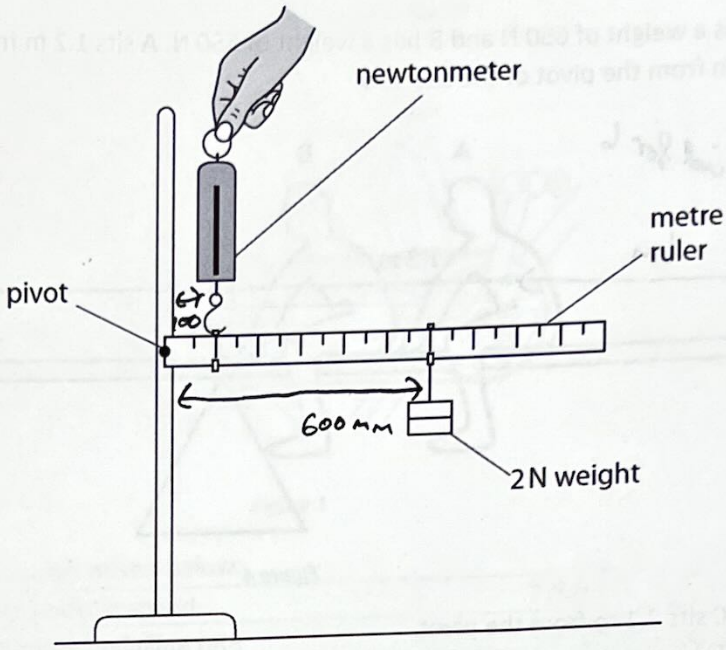


Figure 3

The 2 N weight is placed 600 mm from the pivot.
The newtonmeter is placed 100 mm from the pivot and the setup is in equilibrium.

(a) State the condition that must be true for the setup to be in equilibrium.

The newtonmeter must be exerting a force upwards on the ruler. **[1]** 0

(b) Calculate the reading on the newtonmeter. Ignore the weight of the ruler.

$600 \times 2 = 100 \times x$

$x = \frac{1200}{100} = 12\text{ N}$

Newtonmeter reading ...12 N... **[3]** 3

6. **Figure 4** shows three children, **A, B** and **C** sitting on a balanced, horizontal see-saw of mass 35 kg. The centre of mass of the see-saw is vertically above the pivot.

A has a weight of 650 N and **B** has a weight of 550 N. **A** sits 1.2 m from the pivot and **B** sits 0.5 m from the pivot of the see-saw.

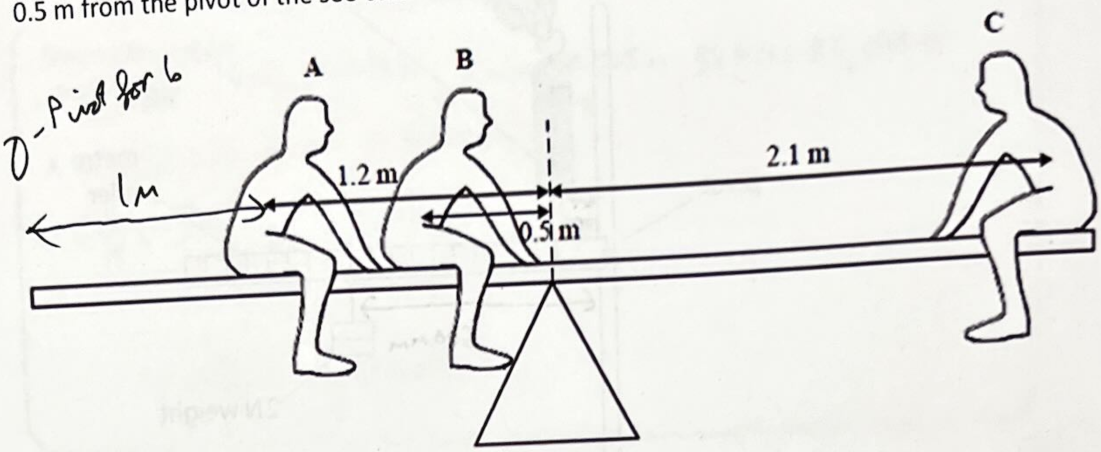


Figure 4

(a) **C** sits 2.1 m from the pivot.
Taking moments about a suitable point, calculate the weight of **C**.

$\sum AC \text{ moments} = \sum C \text{ moments}$

$1.2 \times 650 + 0.5 \times 550 = 2.1x$

$x = \frac{1055}{2.1}$

$= 502.38\ldots$

Weight of **C** ....502N.... **[3]** 3

(b) Calculate the force acting on the pivot of the see-saw.
Gravitational field strength of Earth, $g = 9.81 \text{ N kg}^{-1}$

$\sum AC = \sum C$

$1 \times 650 + 1.7 \times 550 + \frac{1055}{2.1} \times 4.3 = 2.2x$

$x = \frac{3745.23\ldots}{2.2} = 1702.38\ldots$

Force on pivot ....1702.... **[2]** 0

(or just add the ~~masses~~ weights).