School of Mechanical and Manufacturing Engineering

MMAN1300 – ENGINEERING MECHANICS 1

2017 S2 Block Test 2

Instructions:

- Time allowed: 45 minutes
- Total number of questions: 3
- Answer all the questions in the test
- Answer all questions in the spaces provided
- The 6 marks allocations shown are worth 6% of the course overall
- Candidates may bring drawing instruments, rulers and UNSW approved calculators to the test
- Print your name, student ID and all other requested details above
- Record your answers (with appropriate units) in the ***ANSWER BOXES*** provided

Notes:

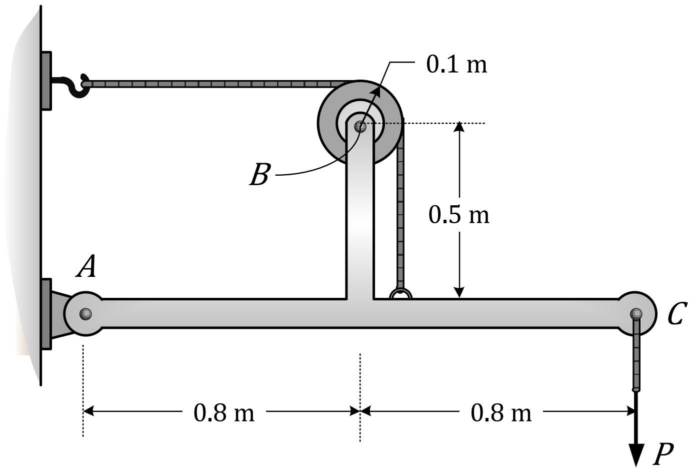
Your work must be complete, clear and logical

Do not skip steps, sign conventions, units and relevant diagrams and clearly state the final answers

No part of this paper is to be retained by candidates until handed back after marking

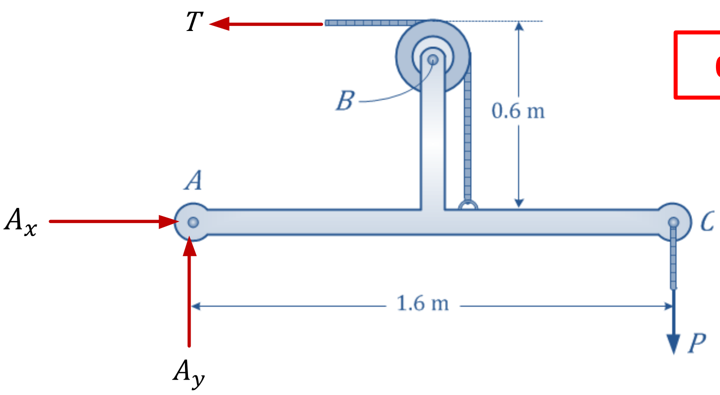
Question 1: (2 Marks)

Determine the greatest force P that can be applied to the frame if the largest force resultant acting at A can have a magnitude of 5 kN. Also find the tension (T) in the cable passing over the pulley.



Solution:

(a) Draw the free body diagram of your chosen system



0.5

(b) Calculate T in terms of P

$+\circlearrowleft \sum M_A = 0$

$T(0.6) - P(1.6) = 0$

$T = \dfrac{P(1.6)}{0.6}$

$T = 2.67\,P$

0.25

(c) Calculate the values of P and T

$+\uparrow \sum F_y = 0$

$A_y - P = 0$ **0.25**

$A_y = P$

$+\rightarrow \sum F_x = 0$

$A_x - T = 0$ **0.25**

$A_x = 2.67\,P$

According to the given condition:

$5 = \sqrt{(2.67P)^2 + (P)^2}$ **0.5**

$P = 1.754\ kN$

$T = 2.67 \times P$

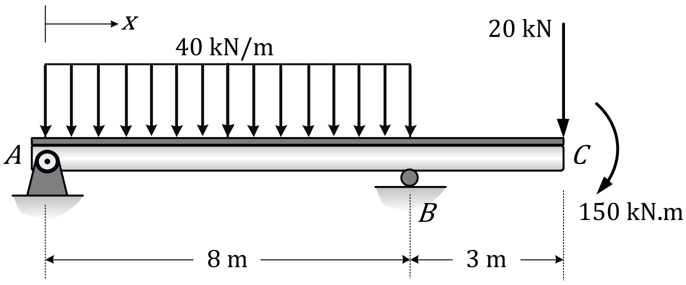
$T = 2.67 \times 1.754$ **0.25**

$T = 3.507\ \mathrm{kN}$

Answers to (c):	$P = 1.754\ \mathrm{kN}$	$T = 3.507\ \mathrm{kN}$

Question 2: (2 Marks)

Draw the shear force and bending moment diagrams for the loaded beam shown below. Determine the location ($x_{M_{max}}$) and value of the maximum bending moment (M_{max}).



Solution:

(a) Calculate the Support Reactions at A and B

$+\rightarrow \sum F_x = 0$

$A_x = 0$

$+\circlearrowleft \sum M_A = 0$

$-320(4) + B_y(8) - 20(11) - 150 = 0$

$B_y = 206.25 \text{ kN}$ **0.25**

$+\uparrow \sum F_y = 0$

$A_y - 320 - 20 + 206.25 = 0$ **0.25**

$A_y = 133.75 \text{ kN}$

(b) Sketch the complete free body diagram, shear force diagram and bending moment diagram, on the axes provided ***on the next page (cross the attempt you do not want to be marked)****:*

(Use this space for relevant working if needed)

$0 \leq x \leq 8$

$+\uparrow \sum F_y = 0$

$133.75 - 40x - V = 0$

$V = 133.75 - 40x$

(Use this space for relevant working if needed)

$+\circlearrowleft \sum M = 0$

$\mathrm{M} + 40\mathrm{x}\left(\frac{\mathrm{x}}{2}\right) - 133.75\mathrm{x} = 0$

$\mathrm{M} = 133.75\mathrm{x} - 20\mathrm{x}^2$

$8 \leq x \leq 11$

$+\uparrow \sum F_y = 0$

$V - 20 = 0$

$V = 20$

$+\circlearrowleft \sum M = 0$

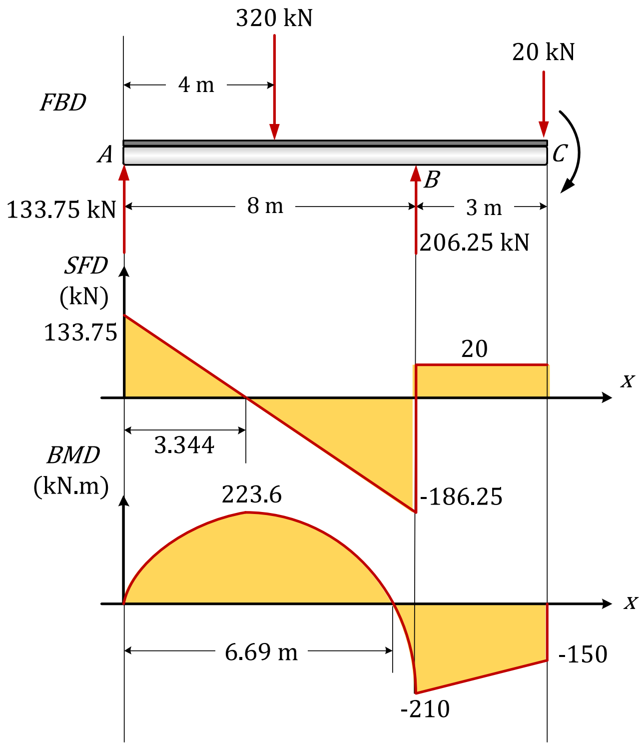
$\mathrm{M} + 20(11 - \mathrm{x}) + 150 = 0$

$\mathrm{M} = 20\mathrm{x} - 150$

Note: If the students have drawn the correct FBD, SFD and BMD, just by inspection (without the method of sections), they should get full marks)

However, equations are needed to solve for the maximum bending moment, therefore more marks have been assigned to the next part.

0.75



Attempt 1

(c) Find the location and magnitude of the maximum bending moment

$\frac{\mathrm{dM}}{\mathrm{dx}} = \frac{\mathrm{d}(133.75\mathrm{x} - 20\mathrm{x}^2)}{\mathrm{dx}} = 0 \quad \rightarrow \quad \mathrm{x} = 3.343\ \mathrm{m}$ **0.5**

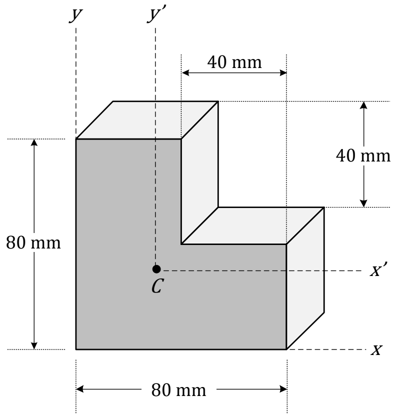
$@\ \mathrm{x} = 3.343\ \mathrm{m}$

$M_{max} = 133.75(3.343) - 20(3.343)^2 = 223.6\ \mathrm{kN.m}$ **0.25**

Answers:	$x_{M_{max}} = 3.343\ \mathrm{m}$	$M_{max} = 223.6\ \mathrm{kN.m}$

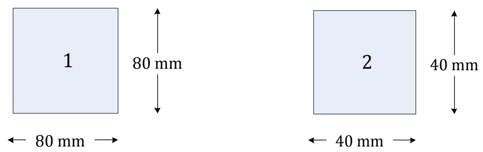
Question 3: (2 Marks)

For the cross-section shown, determine the following: *(Proceed according to the steps in solution boxes).*



Solution:

(a) Determine the coordinates $\bar{x}$ and $\bar{y}$ *to the centroid C*



0.5

$$\bar{x} = \frac{\sum A\tilde{x}}{\sum A} = \frac{(80 \times 80)(40) - (40 \times 40)(40 + 20)}{(80 \times 80) - (40 \times 40)} = 33.33 \text{ mm}$$

$$\bar{y} = \frac{\sum A\tilde{y}}{\sum A} = \frac{(80 \times 80)(40) - (40 \times 40)(40 + 20)}{(80 \times 80) - (40 \times 40)} = 33.33 \text{ mm}$$

(b) Calculate the moment of inertia ($I_{x'x'}$) *and* ($I_{y'y'}$) *about the neutral axis:*

$$I_{x'x'} = \frac{1}{12}(80)(80)^3 - \frac{1}{12}(40)(40)^3$$

$$I_{x'x'} = 3.20\ (10^6)\ \text{mm}^4$$

0.25

Continue your working for part (b) here:

$$I_{y'y'} = \frac{1}{12}(80)(80)^3 - \frac{1}{12}(40)(40)^3$$

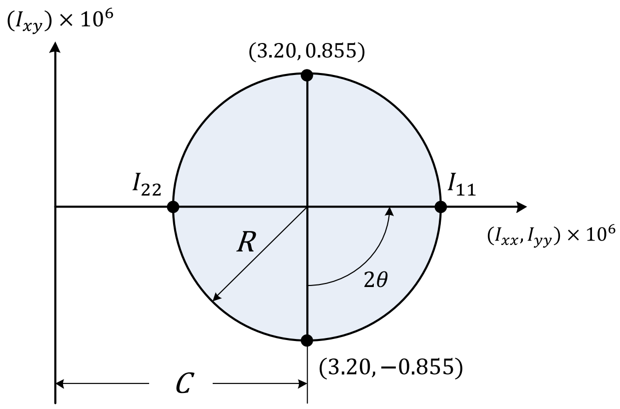
$$I_{y'y'} = 3.20\ (10^6)\ \text{mm}^4$$ **0.25**

(c) Calculate the product of inertia ($I_{x'y'}$) about C

$$I_{x'y'} = (80 \times 80)(40 - 33.33)(40 - 33.33) - (40 \times 40)(60 - 33.33)(60 - 33.33)$$

$$I_{x'y'} = -0.855\ (10^6)\ \text{mm}^4$$ **0.25**

(d) Draw the Mohr's circle and determine the maximum principle moment of inertia I_{11} and I_{22}



0.75

$$I_{11} = C + R = 3.20(10^6) + 0.855(10^6) = 4.05(10^6)\ \text{mm}^4$$

$$I_{22} = C - R = 3.20(10^6) - 0.855(10^6) = 2.35(10^6)\ \text{mm}^4$$

Answers:	$\bar{x} = 3.33$ mm	$I_{x'x'} = 3.2(10^6)$ mm^4	$I_{y'y'} = 3.2(10^6)$ mm^4	$I_{x'y'} = -0.855(10^6)$ mm^4
	$\bar{y} = 3.33$ mm	$I_{11} = 4.05(10^6)$ mm^4	$I_{22} = 2.35(10^6)$ mm^4	

Useful Formulas

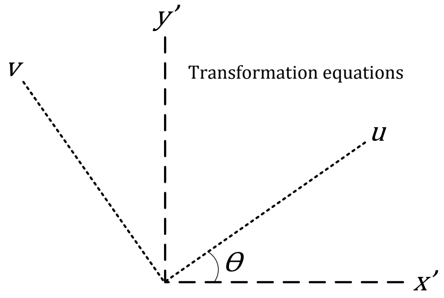
Transformation Equations

$$I_{uu} = \frac{I_{x'x'} + I_{y'y'}}{2} + \frac{I_{x'x'} - I_{y'y'}}{2}\cos 2\theta - I_{x'y'}\sin 2\theta$$

$$I_{vv} = \frac{I_{x'x'} + I_{y'y'}}{2} - \frac{I_{x'x'} - I_{y'y'}}{2}\cos 2\theta + I_{x'y'}\sin 2\theta$$

$$I_{uv} = \frac{I_{x'x'} - I_{y'y'}}{2}\sin 2\theta + I_{x'y'}\cos 2\theta$$

$$I_{11,22} = \frac{I_{x'x'} + I_{y'y'}}{2} \pm \sqrt{\left(\frac{I_{x'x'} - I_{y'y'}}{2}\right)^2 + I_{x'y'}{}^2}$$



Parallel Axis Theorem

$$I_{xx} = I_{x'x'} + A{d_y}^2$$

$$I_{yy} = I_{y'y'} + A{d_x}^2$$

$$I_{xy} = I_{x'y'} + Ad_x d_y$$

Rough work
(Note: No working on this section will be marked)