Student Name: ☞ Solution and Marking Guide

Student ID: ☞ Block Test 2

PSS Room/Demonstrator: ☞

School of Mechanical and Manufacturing Engineering

MMAN1300 – ENGINEERING MECHANICS 1

2018 S1 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:

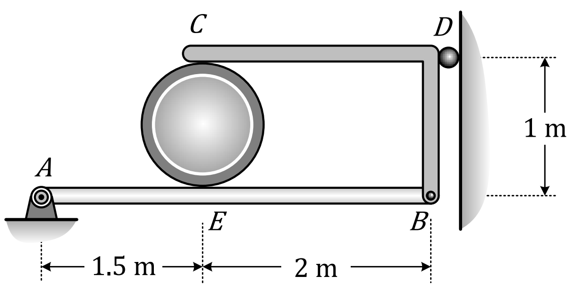
Your work must be complete, clear and logical

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)

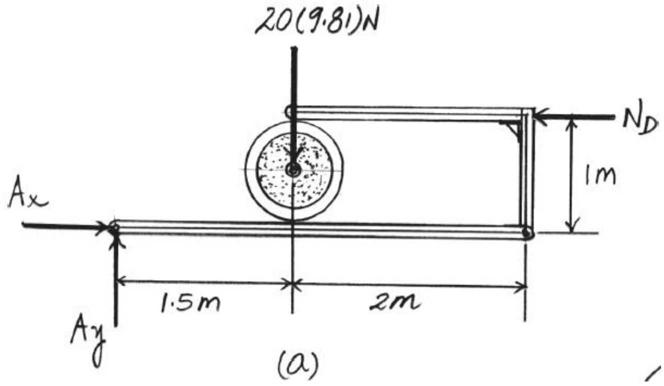
The smooth 20 kg cylinder is supported between members *AB* and *CDB* as shown. Determine the following:



Solution:

(a) Determine the support reactions (A_x and A_y) at joint A – (Include the free body diagram of your chosen system)

Consider FBD of the entire system



0.25

$\circlearrowleft + \sum M_A = 0;$

$N_D(1) - 20(9.81)(1.5) = 0$

$N_D = 294.3$ N

$\rightarrow + \sum F_x = 0;$

$A_x - 294.3 = 0$

$A_x = 294.3$ N 0.25

$\uparrow + \sum F_y = 0;$

$A_y - 20(9.81) = 0$

$A_y = 196.2$ N 0.25

Continue your solution to part (a) here:

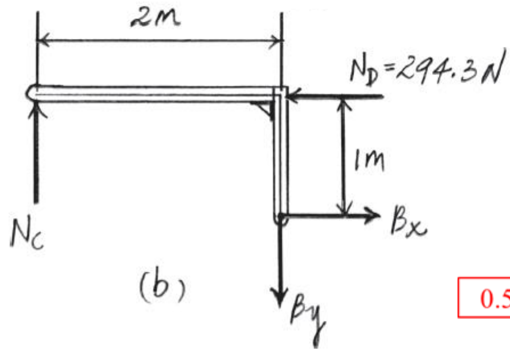
(b) Determine the force (F_{CDB}) exerted by the cylinder on member CDB – (Include the free body diagram of your chosen system)

For member CDB;

$\circlearrowleft +\sum M_B = 0;$

$294.3(1) - N_c(2) = 0$

$N_c = F_{CDB} = 147.15\ N$ 0.25



0.5

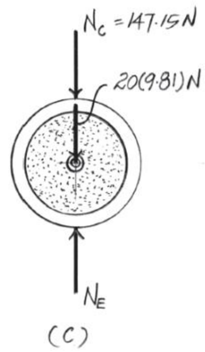
(c) Determine the force (F_{AB}) exerted by the cylinder on member AB – (Include the free body diagram of your chosen system)

$\uparrow +\sum F_y = 0$

$N_E - (20)(9.81) - 147.15 = 0$

$N_E = F_{AB} = 343$ N 0.25

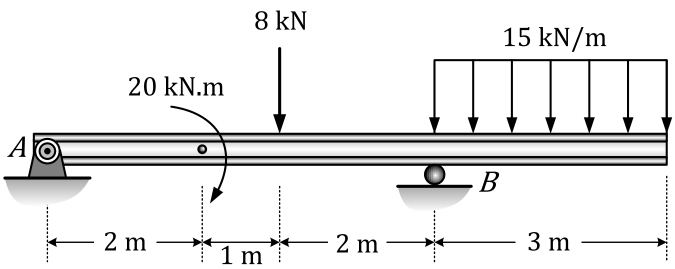
0.25



Answers:	$A_x = 294.3$ N	$A_y = 196.2$ N	F_{CDB} =147.15 N	$F_{AB} = 343$ N

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

Using the FBD

$\circlearrowleft +\sum M_A = 0$

$-20 - 8(3) - (15 \times 3)(6.5) + B_y(5) = 0$

$B_y = 67.3 \text{ kN}$

$\boxed{0.25}$

$\uparrow\ +\sum F_y = 0$

$A_y + B_y - 45 - 8 = 0$

$A_y = 14.3 \text{ kN } (\downarrow)$

$\boxed{0.25}$

(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)

Note for markers: *The students could draw the SF and BM diagram by inspection without actually going through method of sections for the entire length of the beam. Some students might have taken section for only the length subjected to the distributed load which is fine (as that is used to get location of maximum BM). If the students have used their intuition and sensible judgement without actually getting SF and BM as function of x for the entire length, then they should get marks.*

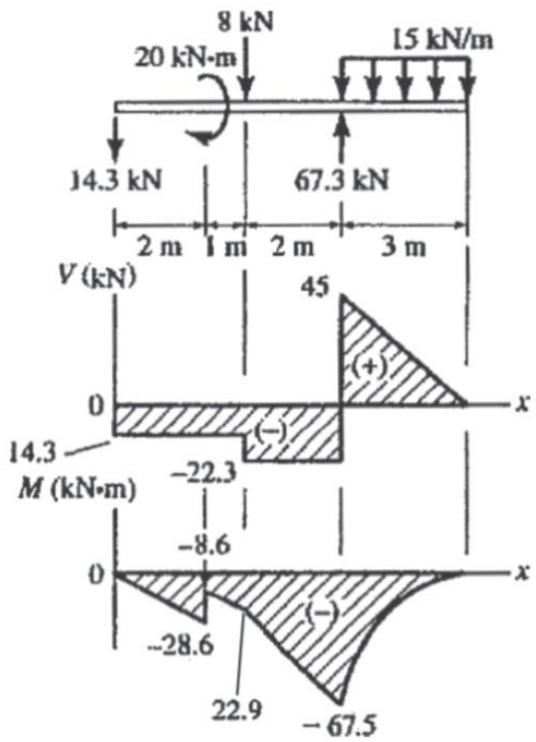
Therefore, maximum marks are assigned to the correct FB, SF and BM diagrams (regardless of their method)

(Use this space for relevant working if needed)

0.25

0.5

0.5



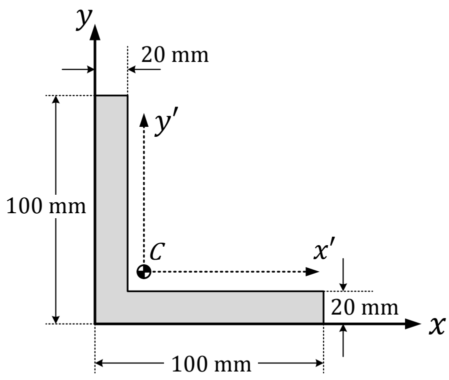
(c) Find the location and magnitude of the maximum bending moment

The students could report the answer either based on inspection or by formulating as function of x

Answers:	$x_{M_{max}} = 5$ m	M_{max} = - 67.5 kN.m 0.25

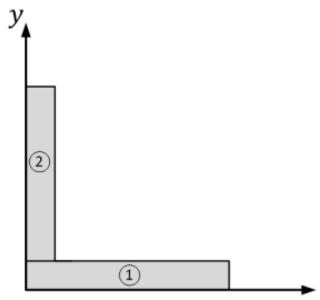
Question 3: (2 Marks)

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*



$$\bar{y} = \frac{\sum \tilde{y}_i A_i}{A_i} = \frac{(10)(100 \times 20) + (60)(80 \times 20)}{(100 \times 20) + (80 \times 20)} = 32.22 \text{ mm}$$

$\boxed{0.25}$

$$\bar{x} = \frac{\sum \tilde{x}_i A_i}{A_i} = \frac{(50)(100 \times 20) + (10)(80 \times 20)}{(100 \times 20) + (80 \times 20)} = 32.22 \text{ mm}$$

$\boxed{0.25}$

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

$$I_{x'x'} = \left[\frac{1}{12}(100)(20)^3 + (100 \times 20)(32.22 - 10)^2\right] + \left[\frac{1}{12}(20)(80)^3 + (80 \times 20)(32.22 - 60)^2\right]$$

$I_{x'x'} = 3.1422 \times 10^6 \text{ mm}^4$ $\boxed{0.25}$

$$I_{y'y'} = \left[\frac{1}{12}(20)(100)^3 + (100 \times 20)(32.22 - 50)^2\right] + \left[\frac{1}{12}(80)(20)^3 + (80 \times 20)(32.22 - 60)^2\right]$$

$I_{y'y'} = 3.1422 \times 10^6 \text{ mm}^4$ $\boxed{0.25}$

Continue your working for part (b) here:

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

$I_{x'y'} = (100 \times 20)(50 - 32.22)(10 - 32.22) + (80 \times 20)(10 - 32.22)(60 - 32.22)$

$I_{x'y'} = (2000)(17.78)(-22.22) + (1600)(-20.22)(27.78)$

$I_{x'y'} = -1.778 \times 10^6 \text{ mm}^4$ 0.25

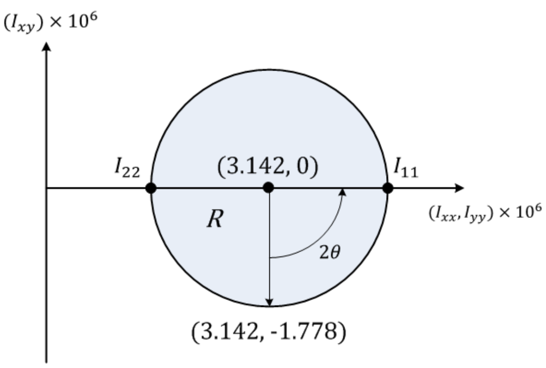
(d) Draw the Mohr's circle and determine the maximum principle moment of inertia I_{11} and I_{22}

$R = \sqrt{\left(\frac{I_{x\prime x\prime} - I_{y\prime y\prime}}{2}\right)^2 + I_{xy}{}^2} = -1.778 \times 10^6 \text{ mm}^4$

$I_{11} = C + R = 3.1422(10^6) + 1.778(10^6) = 4.92(10^6) \text{ mm}^4$

0.25

$I_{22} = C - R = 3.1422(10^6) - 1.778(10^6) = 1.36(10^6) \text{ mm}^4$



0.5

Answers:	$\bar{x} = 32.22$ mm	$\bar{y} = 32.22$ mm	$I_{x\prime x\prime} = 3.1422(10^6)$ mm^4	$I_{y\prime y\prime} = 3.1422(10^6)$ mm^4
	$I_{xy} = -1.778 \times 10^6$ mm^4	$I_{11} = 4.92(10^6)$ mm^4	$I_{22} = 1.36(10^6)$ mm^4	

Useful Formulas

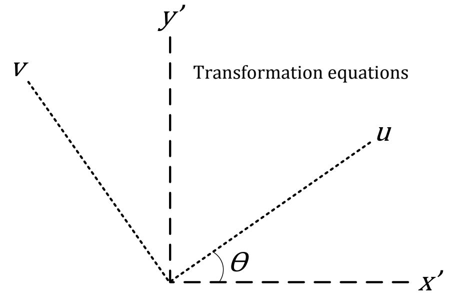
Transformation Equations

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

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

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

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



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)