THE UNIVERSITY OF NEW SOUTH WALES
SCHOOL OF MECHANICAL AND MANUFACTURING ENGINEERING

August 2017
MMAN1300 – ENGINEERING MECHANICS 1
Block Test - 1

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 marks allocations shown will be scaled to 6 basic marks.

Candidates may bring drawing instruments, rules and UNSW approved calculators to the test

Print your name, student ID and PSS allocation on top right corner of the question paper

Record your answers (with appropriate units) in the ***ANSWER BOXES*** provided

Notes:

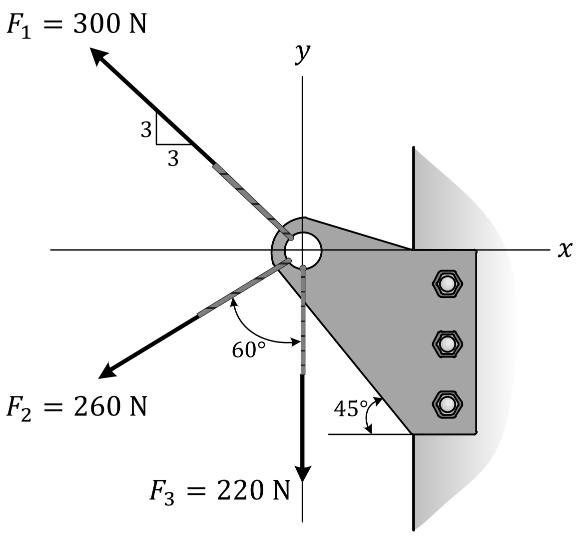
Your work must be complete, clear and logical

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)

A steel bracket fixed into a wall with three bolts is loaded by three cables as shown. Determine the magnitude of the resultant force of the three cables combined and its direction measured counterclockwise from the positive x-axis. *(Proceed according to the steps in solution boxes)*



Solution:

Present your solution to Question-1 here (show complete working including any diagrams if needed to support your answer)

The x components of all the forces:

$$F_{1x} = -\,300\cos 45° \ \ \text{(N)}$$
$$F_{2x} = -\,260\sin 60° \ \ \text{(N)}$$
$$F_{3x} = 0 \ \ \text{(N)}$$

0.5

The y components of all the forces:

$$F_{1y} = +\,300\sin 45° \ \ \text{(N)}$$
$$F_{2y} = -260\cos 60° \ \ \text{(N)}$$
$$F_{3y} = -\,220 \ \ \text{(N)}$$

0.5

Continue your solution to Question-1 here:

Resultant force in *x* - direction:

$$F_{Rx} = F_{1x} + F_{2x} + F_{3x}$$

$$F_{Rx} = -\,300\cos 45° - \;260\sin 60° + 0$$

$$F_{Rx} = -437.3\;\;(\mathrm{N})\qquad \boxed{\mathbf{0.25}}$$

Resultant force in *y* - direction:

$$F_{Ry} = F_{1y} + F_{2y} + F_{3y}$$

$$F_{Ry} = 300\sin 45° - \;260\cos 60° - 220$$

$$F_{Ry} = -137.86\;\;(\mathrm{N})\qquad \boxed{\mathbf{0.25}}$$

Magnitude of resultant force:

$$F_R = \sqrt{(F_{Rx})^2 + \left(F_{Ry}\right)^2}$$

$$F_R = \sqrt{(-437.3\;)^2 + (-137.86)^2} = 458.52\;(\mathrm{N})\qquad \boxed{\mathbf{0.25}}$$

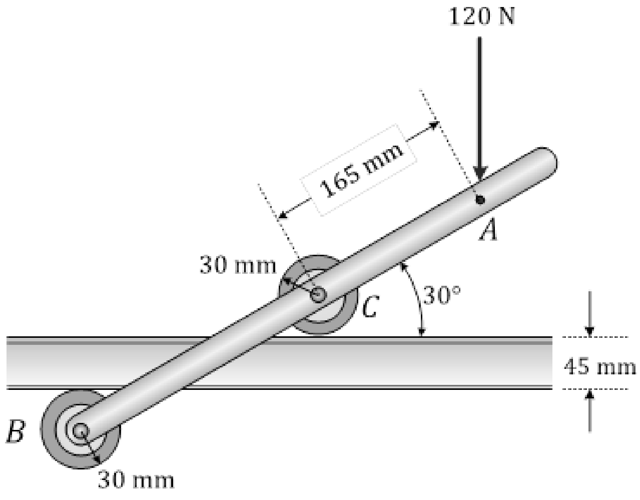
Direction of resultant force measured counterclockwise from the positive x-axis:

$$\theta = 180° + \;\tan^{-1}\left(\frac{137.86}{437.3}\right) = 197.5°\qquad \boxed{\mathbf{0.25}}$$

Answers:	$\lvert F_R \rvert = 458.52\ \mathrm{N}$	$\theta = 197.5°$

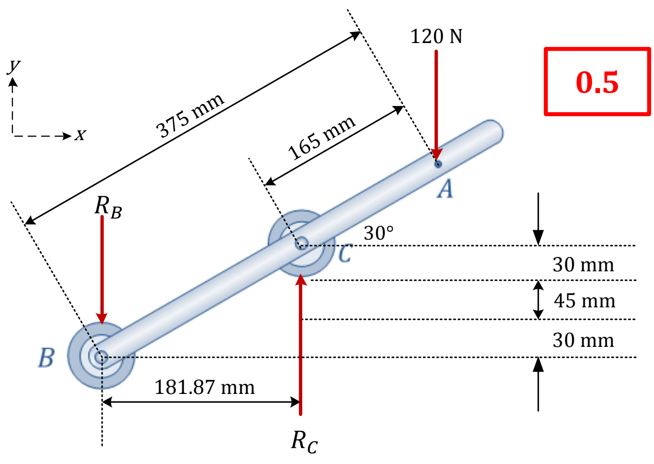
Question 2: (2 Marks)

The device shown is designed to apply pressure when bonding laminate to each side of a countertop near an edge. If a 120-N force is applied to the handle, determine the force which each roller exerts on its corresponding surface. *(Proceed according to the steps in solution boxes)*

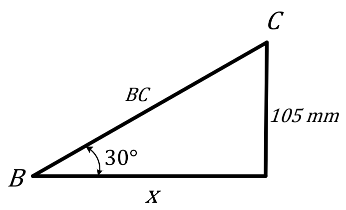


Solution:

Draw the Free Body Diagram



0.5



Calculation of distance AB in above FBD:

$$AB = 165 \text{ mm} + \left(\frac{105}{\sin 30°}\right) \text{ mm} = 375 \text{ mm}$$ **0.25**

Calculation of horizontal distance between B and C in above FBD:

$$x = \left(\frac{105}{\tan 30°}\right) \text{ mm} = 181.87 \text{ mm}$$ **0.25**

Force exerted by roller B on its corresponding surface

$$+\circlearrowleft \sum M_C = 0$$

$$R_B(181.87) - 120(165\cos 30°) = 0$$

$$R_B = 94.283\ (N)$$

0.25

Force exerted by roller C on its corresponding surface

$$+\uparrow \sum F_y = 0$$

$$-R_B + R_C - 120 = 0$$

$$-94.283 + R_C - 120 = 0$$

$$R_C = 214.283\ (N)$$

0.5

Given the same system, what will be the force exerted by rollers B and C on their corresponding surfaces if the applied load of 120 N acts upward?

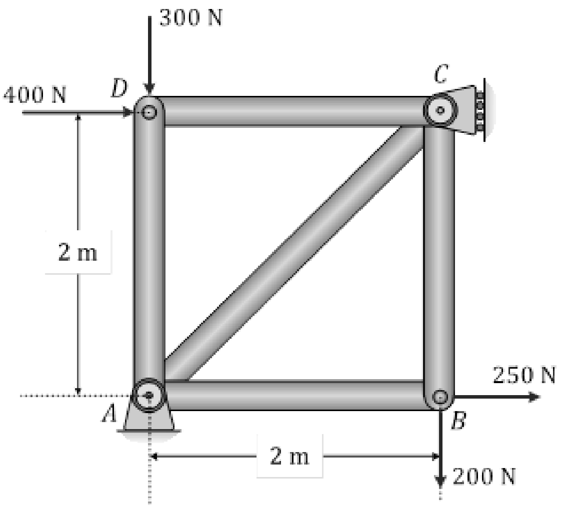
If the 120 N, was acting upward, then at the instant shown, the force on both rollers would be zero because of the loss of contact at both points.

0.25

Answers:	$R_C = 214.283$ N	$\theta = 90°$

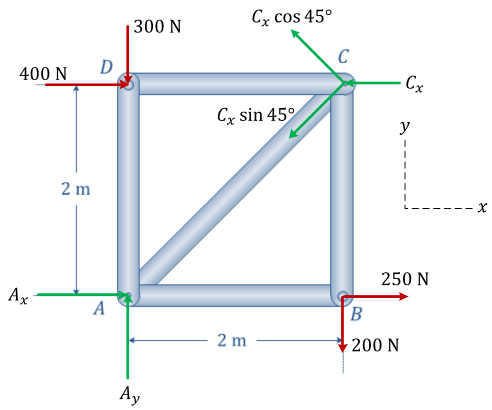
Question 3: (2 Marks)

The truss is loaded by the four forces as shown. Determine the following: *(Proceed according to the steps in solution boxes)*



Solution:

(a) Draw the Free body diagram



0.2

(b) Determine the support reactions at A and C

$+\circlearrowleft \sum M_A = 0$ $$-400(2) + (C_x \cos 45°)(\sqrt{8}) - 200(2) = 0$$ **0.2**

$$C_x = 600 \text{ (N)}$$

$+\uparrow \sum F_y = 0$ $$-300 - 200 + A_y = 0$$ **0.2**

$$A_y = 500 \text{ (N)}$$

$+\rightarrow \sum F_x = 0$ $$400 + 250 - 600 + A_x = 0$$

$$A_x = -50 \text{ (N)}$$ **0.2**

(c) Using **Method of Joints**, determine the forces in members AB, AD, BC and DC

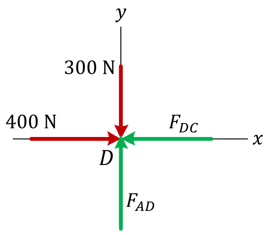
<u>Joint D:</u>

$\boxed{0.1}$

$+\rightarrow \sum F_x = 0 \qquad 400 - F_{DC} = 0 \qquad F_{DC} = 400\text{ N (C)}$

$\boxed{0.1}$

$+\uparrow \sum F_y = 0 \qquad -300 + F_{AD} = 0 \qquad F_{AD} = 300\text{ N (C)}$



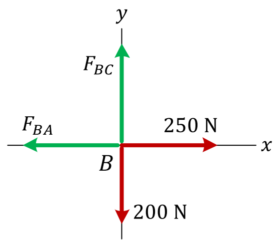
<u>Joint B:</u>

$\boxed{0.1}$

$+\rightarrow \sum F_x = 0 \qquad 250 - F_{BA} = 0 \qquad F_{BA} = 250\text{ N (T)}$

$\boxed{0.1}$

$+\uparrow \sum F_y = 0 \qquad -200 + F_{BC} = 0 \qquad F_{BC} = 200\text{ N (T)}$



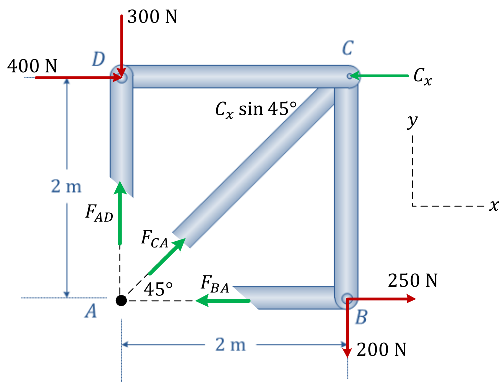
(d) Using **Method of Sections**, determine the forces in member AC

$\boxed{0.2}$

$$+\circlearrowleft \sum M_C = 0$$

$$(600)(2) - (300)(2) - (F_{CA}\sin 45°)(2) + (300)(2) - (400)(2) = 0$$

$F_{CA} = 283\text{ N (C)}$ $\boxed{0.25}$

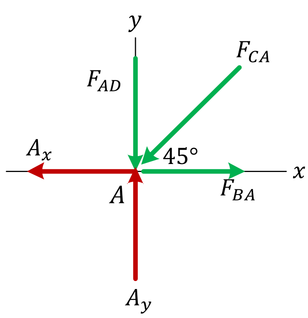


(e) Use your results from (b), (c) and (d) to check equilibrium of joint A.

$+\rightarrow \sum F_x = 0 \qquad -A_x + F_{BA} - F_{CA}\sin 45° = 0$

$+\uparrow \sum F_y = 0 \qquad A_y - F_{AD} - F_{CA}\cos 45° = 0$ $\boxed{0.3}$

(Both Confirms)



Answers:	$F_{AD} = 300\text{ N (C)}$	$F_{CD} = 400\text{ N (C)}$	$F_{AB} = 250\text{ N (T)}$
	$F_{BC} = 200\text{ N (T)}$	$F_{AC} = 283\text{ N (C)}$	

Equation Sheet

Linear motion

$$v = \frac{ds}{dt} \qquad a = \frac{dv}{dt} \qquad vdv = ads$$

Constant linear acceleration equations $(t_o = 0)$

$$v = v_o + at \qquad v^2 = v_o^2 + 2a(s - s_o) \qquad s = s_o + v_o t + \frac{1}{2}at^2$$

Angular motion

$$\omega = \frac{d\theta}{dt} \qquad \alpha = \frac{d\omega}{dt} \qquad \omega d\omega = \alpha d\theta$$

Displacement, velocity and acceleration components

Rectangular coordinates

$$\mathbf{r} = x\mathbf{i} + y\mathbf{j} \qquad \mathbf{v} = \dot{x}\mathbf{i} + \dot{y}\mathbf{j} \qquad \mathbf{a} = \ddot{x}\mathbf{i} + \ddot{y}\mathbf{j}$$

Normal and tangential coordinates

$$\mathbf{v} = v\mathbf{e_t} \qquad \mathbf{a} = a_t\mathbf{e_t} + a_n\mathbf{e_n} \qquad v = \omega r \qquad a_t = \dot{v} = \alpha r \qquad a_n = \frac{v^2}{\rho} = \omega^2 r$$

Relative motion

$$\mathbf{r}_A = \mathbf{r}_B + \mathbf{r}_{A/B} \qquad \mathbf{v}_A = \mathbf{v}_B + \mathbf{v}_{A/B} \qquad \mathbf{a}_A = \mathbf{a}_B + \mathbf{a}_{A/B}$$

Equation of motion (Newton's 2nd law)

$$\sum \mathbf{F} = m\mathbf{a}$$

Work-Energy

$W_{1-2} = \Delta T + \Delta V_g + \Delta V_e \qquad W_{1-2} = F\Delta s$ and/or $M\Delta\theta$

$\Delta T = \frac{1}{2}m\left(v_2^2 - v_1^2\right)$ and/or $\frac{1}{2}I\left(\omega_2^2 - \omega_1^2\right)$

$\Delta V_g = mg(h_2 - h_1)$

$\Delta V_e = \frac{1}{2}k\left(x_2^2 - x_1^2\right)$ for a linear spring

For a rigid body in plane motion

$$\sum \mathbf{F} = m\mathbf{a} \qquad \sum M = I\alpha$$

Mass moment of inertia $\quad I = \int r^2 dm$

Centroid of a cross-section:

$$\bar{x} = \frac{\int x dA}{\int dA} = \frac{\sum_i x_i A_i}{\sum_i A_i} \quad , \quad \bar{y} = \frac{\int y dA}{\int dA} = \frac{\sum_i y_i A_i}{\sum_i A_i}$$

DATA: Acceleration in free fall due to gravity g = 9.81 m/s^2