Student Name: ☞ SOLUTION/MARKING CRITERIA

Student ID: ☞ MMAN1300 – BT1

PSS Room/Demonstrator: ☞

THE UNIVERSITY OF NEW SOUTH WALES

SCHOOL OF MECHANICAL AND MANUFACTURING ENGINEERING

March 2018

MMAN1300 – ENGINEERING MECHANICS 1

Block Test - 1

Instructions:

Time allowed: 45 minutes

Total number of questions: 3

Answer ALL the 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:

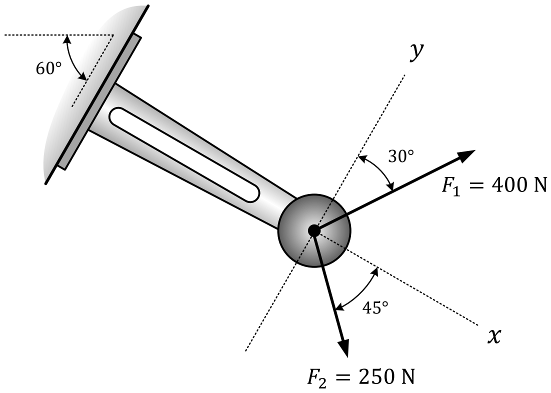
Your work must be complete, clear and logical

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 member is subjected to forces $F_1 = 400$ N and $F_2 = 250$ N, as shown. Determine the magnitude and direction of the resultant force measured counterclockwise from the positive x-axis



Solution:

Present your solution to Question 1 here:

Resolve both forces into x-y components

$(F_1)_x = 400 \sin 30^\circ = 200$ N

$(F_1)_y = 400 \cos 30^\circ = 346.41$ N

0.25

$(F_2)_x = 250 \cos 45^\circ = 176.78$ N

$(F_2)_y = 250 \sin 45^\circ = 176.78$ N

0.25

The resultant force in x-direction

$(F_R)_x = (F_1)_x + (F_2)_x$

$= 200 + 176.78$

$= 376.78$ N

0.25

Continue your solution to Question 1 here:

The resultant force in y-direction.

$$(F_R)_y = (F_1)_y + (F_2)_y$$

$$(F_R)_y = 346.41 - 176.78$$

$$= 169.63 \text{ N}$$ 0.25

The resultant force is :

$$F_R = \sqrt{(376.78)^2 + (169.63)^2}$$

$$F_R = 413.2 \text{ N}$$ 0.5

The direction angle θ is given as :

$$\theta = \tan^{-1}\left(\frac{F_{Ry}}{F_{Rx}}\right)$$

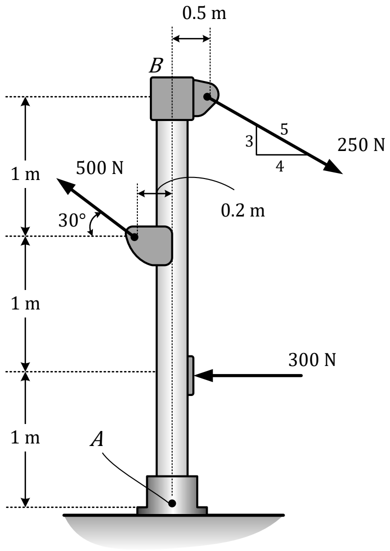
$$\theta = \tan^{-1}\left(\frac{169.63}{376.78}\right)$$

$$\theta = 24.23^\circ$$ 0.5

Answers:	$\lvert F_R \rvert =$ 413.2 N	$\theta =$ 24.23°

Question 2: **(2 Marks)**

Replace the force system acting on the post by a resultant force, and specify where its line of action intersects the post *AB* measured from point *B*. *(Proceed according to the steps in solution boxes)*



Solution:

(a) Determine the magnitude of the equivalent resultant force

$\xrightarrow{+} [\Sigma F_x] = F_x$

$(F_R)_x = 250\left(\frac{4}{5}\right) - 500 \cos 30^\circ - 300$

$= -533.01 \text{ N}$ 0.25

$+\uparrow [\Sigma F_y] = F_y$

$(F_R)_y = -250\left(\frac{3}{5}\right) + 500 \sin 30^\circ$

$= 100 \text{ N}$ 0.25

The magnitude of the resultant force :

$|F_R| = \sqrt{(533.01)^2 + (100)^2}$

$|F_R| = 542.31 \text{ N}$ 0.25

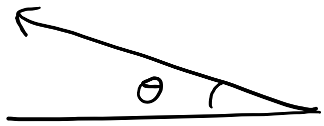
(b) Determine the direction of the equivalent resultant force, measured from positive x-axis

$$\theta = \tan^{-1}\left[\frac{(F_R)_y}{(F_R)_x}\right]$$

$$\theta = \tan^{-1}\left[\frac{100}{533.01}\right]$$

$$\theta = 10.63^\circ$$

0.25



(c) Location of the resultant force

Applying the principle of moments

$$+\circlearrowleft\ \Sigma(M_R)_B = \Sigma M_B$$

$$-533.01\,(d) = -500\cos 30^\circ(1) - 500\sin 30^\circ(0.2)$$

$$-250\left(\frac{3}{5}\right)(0.5) - 300(2)$$

which gives :

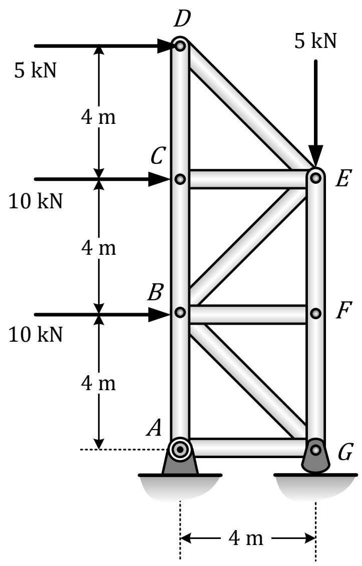
$$d = 2.17\ m$$

01

Answers:	$\lvert F_R\rvert =$ 542.31 N	$\theta =$ 10.63°	$y =$ 2.17 m

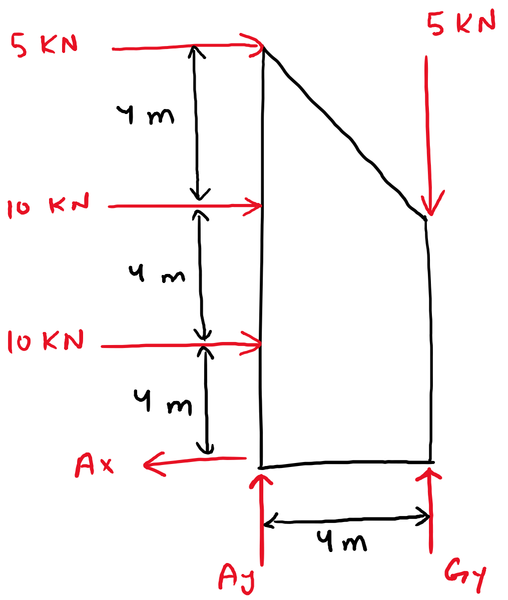
Question 3: **(2 Marks)**

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 of the whole truss



0.2

(b) Determine the support reactions at A and G

$+\circlearrowleft \ \Sigma M_A = 0$

$G_y(4) - 10(4) - 10(8) - 5(12) - 5(4) = 0$

$G_y = 50 \text{ KN } (\uparrow)$ 0.1

$+\uparrow \ \Sigma F_y = 0$

$-5 + 50 + A_y = 0$

$A_y = -45 \text{ KN } (\uparrow)$

or $A_y = 45 \text{ KN } (\downarrow)$ 0.1

$\overset{+}{\rightarrow} \ \Sigma F_x = 0$

$5 + 10 + 10 - A_x = 0$

$A_x = 25 \text{ KN } (\leftarrow)$

0.1

(c) *Using Method of Sections, determine the magnitude and nature (tensile or compressive) of forces in members CB, BE and EF*

$\xrightarrow{+} \Sigma F_x = 0$

$10 + 5 - F_{BE} \cos 45° = 0$

$F_{BE} = 21.2 \text{ kN } (T)$ 0.2

$+\circlearrowleft \Sigma M_B = 0$

$-10(4) - 5(8) - 5(4) - F_{EF}(4) = 0$

$F_{EF} = -25 \text{ kN } (T)$

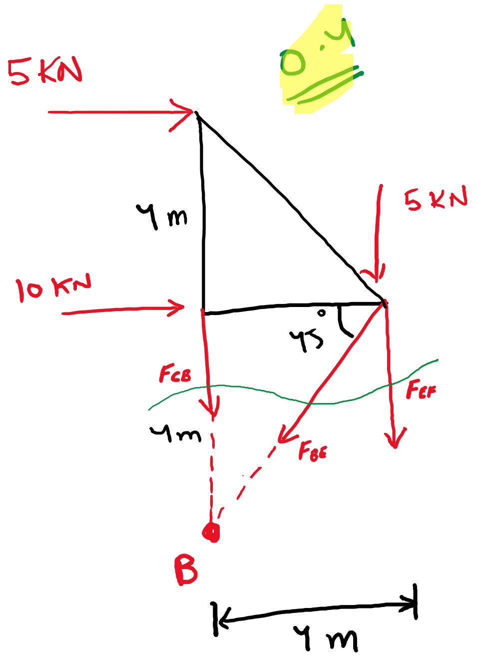
or $F_{EF} = 25 \text{ kN } (c)$ 0.2

$+\uparrow \Sigma F_y = 0$

$-5 - F_{EF} - F_{BE} \sin 45° - F_{CB} = 0$

$-5 - (-25) - 21.2 \sin 45° = F_{CB}$

$F_{CB} = 5 \text{ kN } (T)$ 0.2



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

From joint F $\rightarrow$ $F_{BF} = 0$

For joint B

$\xrightarrow{+} \Sigma F_x = 0$

$10 + 21.2 \cos 45° + F_{BG} \cos 45° = 0$

$F_{BG} = -35.342 \ (T)$

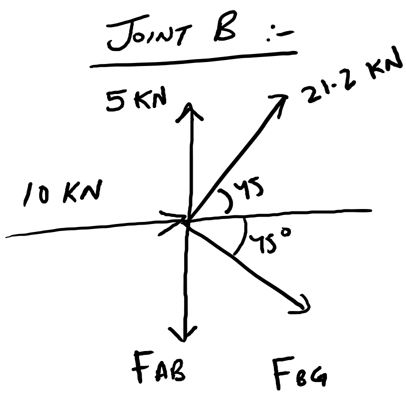
$+\uparrow \Sigma F_y = 0$

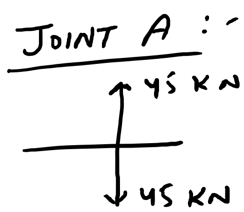
$-F_{AB} + 21.2 \sin 45° + 5 - F_{BG} \sin 45° = 0$

$F_{AB} = 45 \text{ KN } (T)$

confirms to equilibrium of A in vertical direction

0.5





Answers:	F_{CB} = 5 KN (T)	F_{BE} = 21.2 KN (T)	F_{EF} = 25 KN (C)

Equation Sheet

<u>Linear motion</u>

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

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

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

<u>Displacement, velocity and acceleration components</u>

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

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

<u>Relative motion</u>

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

<u>Equation of motion (Newton’s 2nd law)</u>

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

<u>Work-Energy</u>

$W_{1-2} = \Delta T + \Delta V_g + \Delta V_e \qquad W_{1-2} = F\Delta s$ 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

<u>For a rigid body in plane motion</u>

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

<u>Mass moment of inertia</u> $I = \int r^2 dm$

<u>Centroid of a cross-section</u>:

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

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