School of Mechanical and Manufacturing Engineering

MMAN1300 – ENGINEERING MECHANICS 1

2017 S2 Block Test 4

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:

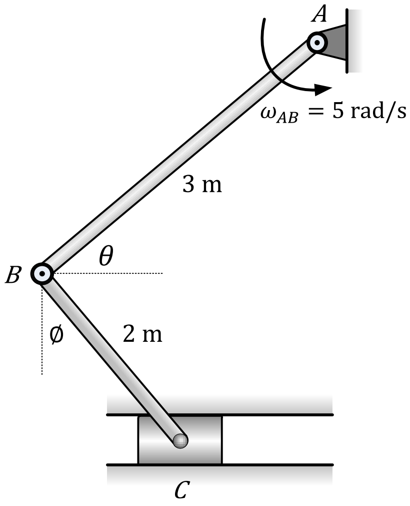
Your work must be complete, clear and logical

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 angular velocity of link *AB* is $\omega_{AB} = 5$ rad/s. Determine the velocity of block *C* and the angular velocity of link *BC* at the instant $\theta = 40°$ and $\emptyset = 30°$.



Solution:

Perform the relative velocity analysis for link AB:

$$v_B = v_A + v_{B/A}$$

Draw the velocity triangle for the following velocities (directions are essential for all three velocities):

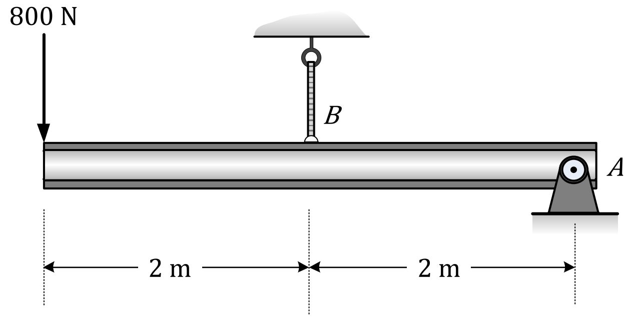
$$v_C = v_B + v_{C/B}$$

Obtain the velocity of the slider block C (v_C) and the angular velocity of link BC (ω_{BC}):

Answers:	$v_C =$	$\omega_{BC} =$

Question 2: (2 Marks)

If the cord at *B* suddenly fails, determine the horizontal and vertical components of the initial reaction at the pin *A*, and the angular acceleration of the 120 kg beam. Treat the beam as a uniform slender rod.



Solution:

Present your solution here (including the free-body diagram if needed):

If needed *use the following information:*

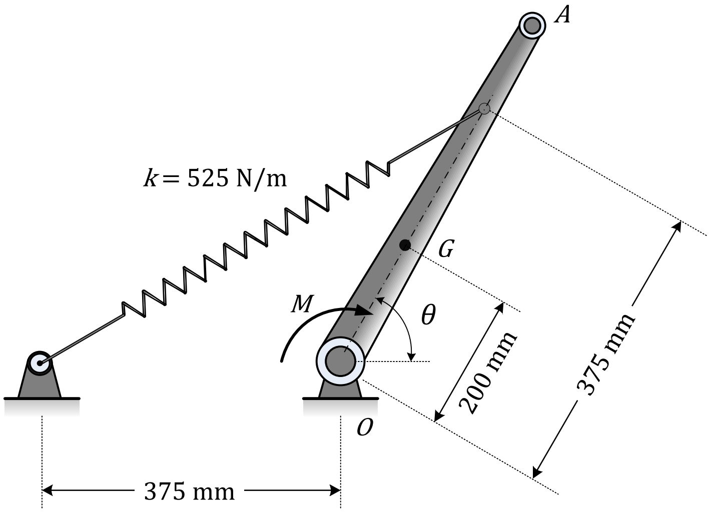
Normal component of acceleration = $r\omega^2$
Tangential component of acceleration = αr
Mass moment of inertia of a slender rod about its centre of mass = $ml^2/12$

Continue your solution (question 3) here:

Answers:	$A_x =$	$A_y =$	$\alpha =$

Question 3: (2 Marks)

The 5.5 kg lever *OA* with mass moment of inertia of $0.344\ \mathrm{kgm^2}$ about *O*, is initially at rest in the vertical position ($\theta = 90°$), where the attached spring of stiffness $k = 525\ \mathrm{N/m}$ is unstretched. Calculate the constant moment *M* applied to the lever through its shaft at *O* which will give the lever an angular velocity $\omega = 4\ \mathrm{rad/s}$ as the lever reaches the horizontal position $\theta = 0$.



Solution:

Present your solution to Question-3 here:

Continue your solution to Question-3 here:

Answers:	$M =$

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

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

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

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

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

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

Quadratic formula:

For: $ax^2 + bx + c = 0$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$