UTHM
Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN IIUSSEIN ONN MALAYSIA

FINAL EXAMINATION
(ONLINE)
SEMESTER I
SESSION 2020/2021

COURSE NAME	:	DYNAMICS
COURSE CODE	:	BDA 20103
PROGRAMME	:	BDD
DATE	.	JANUARY/FEBRUARY 2021
DURATION	:	3 HOURS
INSTRUCTIONS	:	ANSWER **FIVE (5)** QUESTIONS ONLY OUT OF **SIX (6)** QUESTIONS

THIS QUESTIONS PAPER CONSIST OF **EIGHT (8)** PAGES

Q1 A wet ball made from clay is throw at 0.5 m height from ground level with initial velocity of 15 m/s at angle of inclination 40 degrees to the horizontal line. At the same time a needle bullet 15 m distance from the ball throwing is shot vertically upwards and hits the ball.

(a) Analyzed the initial velocity of the needle bullet fired.

(8 marks)

(b) If the needle is embedded in the ball after the impact.

(i) Determine the velocity of the needle and ball after the impact. Let say the mass of the ball and needle are $5P$ and $?\ Q$ gram, respectively. Where:

P – The last digit of your matrix number

Q – The fifth digit of your matrix number

For example, a student with the matrix number CD190987 will have the values of $5P - 57$ and $2.Q - 2.8$.

(7 marks)

(ii) Project the location of the ball and needle falls to the ground.

(5 marks)

Q2 A smooth spiral track is built to channel package from top $0.9R$ m height to bottom level. The entrance at top and the exit at bottom of the spiral track is inline and same direction. The package is then free to slide until stop by itself on the straight lane after exit the spiral track before pushed to the transverse direction by a pusher. The position of package travel along the spiral track is given by a vector

$$\boldsymbol{r} \quad (0.5PQ)\sin(2\pi t)\boldsymbol{i} + (0.5PQ)\cos(2\pi t)\boldsymbol{j} + (0.9R)(1-0.25t)\boldsymbol{k}\ \text{m}$$

measured from center of spiral track at the bottom. The angle for sine and cosine is in radian and time t in seconds. Meanwhile $\boldsymbol{i}$, $\boldsymbol{j}$ and $\boldsymbol{k}$ are unit vector unit in x, y and z direction, respectively. The coefficient of kinetic friction between package and the straight lane surface is $\mu_k - 0.3P$. Where:

P – The last digit of your matrix number

Q – The fifth digit of your matrix number

R – The forth digit of your matrix number

For example, a student with the matrix number CD190987 will have the values of $0.5PQ$ = 0.578, $0.9R$ = 0.99 and $0.3P$=0.37.

(a) What are the magnitude and direction of velocity, v and acceleration, a of package after 2 seconds enter the spiral track.

(8 marks)

(b) Determine when the package exit the spiral track.

(2 marks)

(c) Analyze the velocity v (magnitude and direction) of the package at the exit of the spiral track.

(3 marks)

(d) What are the distance of the pusher placed from the spiral track exit if the mass of the package is 2 kg?

(7 marks)

Q3 Crank AB that rotates along 2D plane is shown in **Figure Q3**. Given the crank rotating with a constant angular velocity of 5 rad/s:

(a) Define a relationship between the block C horizontal displacement and the angles, θ, ϕ between the linkages.

(2 marks)

(b) Define a relationship between point B vertical position and the angles, θ, ϕ between the linkages.

(2 marks)

(c) Using to the answer in a) and b), prove that the relationship between horizontal displacement of block C and angle, θ is given by:

$$x = 0.6\cos\theta + 0.3\sqrt{2\sin\theta - 4\sin^2\theta + 0.75}$$

(2 marks)

(d) Determine the velocity of block C when $\theta = 30°$ *(Note: 2 sinθcosθ = sin 2θ)*.

(8 marks)

(e) Using the answer in (ii), define the angular velocity of link BC when $\theta = 30°$

(6 marks)

Q4 (a) **Figure Q4(a)** shows a system consists of rod AB that rotates at ω_{AB}= 52 rad/s about the fixed point A. Suppose the rod CD is fixed using pin at point C:

(i) Locate the instantaneous center of zero velocity (IC) of the system.

(4 marks)

(ii) Determine the angular velocity of the rod CD at the instant shown

(4 marks)

(b) **Figure Q4(b)** shows a gear set Given the center of the gear set rolls at 8m/s, while the gear rack B is set fixed.

(i) Locate the instantaneous center of zero velocity (IC) of the smaller gear.

(4 marks)

(ii) Determine the magnitude and direction of velocity at point A.

(8 marks)

Q5 (a) The material of thin plate shown in **Figure Q5(a)** has a mass per unit area of 10 kg/m^2. Determine the mass moment of inertia of the thin plate about an axis perpendicular to the page and passing through point *O*. (6 marks)

(b) A race car has a mass of 1200 kg and a center of mass at *G* as shown in **Figure Q5(b)**. Neglect the mass of the wheels and assume the engine is disengaged so that the wheels are free to roll. If a braking parachute is attached at *C* and provides a horizontal braking force of $F - (1.6v^2)$ N , where v is in meters per second,

(i) Draw the free-body diagram and determine the critical speed the car can have upon releasing the parachute, such that the wheels at *B* are on the verge of leaving the ground that is the normal reaction at *B* is zero.

(ii) If such a condition occurs, determine the car's initial deceleration.

(8 marks)

(c) A motor supplies a constant torque $M = 2$ N.m to a 25 mm radius shaft O connected to the center of the 30 kg flywheel as shown in **Figure Q5(c)**. The resultant bearing friction F, which the bearing exerts on the shaft, acts tangent to the shaft and has a magnitude of 50 N. Determine how long the torque must be applied to the shaft to increase the flywheel's angular velocity from 4 rad/s to 15 rad/s. The flywheel has a radius of gyration $k_O = 0.15$ m about its center O.

(6 marks)

Q6 (a) The pendulum of the Charpy impact machine has a mass of 50 kg and a radius of gyration of $k_A = 1.75$ m as shown in **Figure Q6(a)**. If it is released from rest when $\theta = 0°$, determine its angular velocity just before it strikes the specimen S at $\theta = 90°$ by using principle of work and energy.

(8 marks)

(b) The 30 kg pendulum has its mass center at G and a radius of gyration about point G of $k_G = 300$ mm as shown in **Figure Q6(b)**. If it is released from rest when $\theta = 0°$, determine its angular velocity at the instant $\theta = 90°$ by using conservation of energy's principle. Spring AB has a stiffness of $k = 300$ N/m and is unstretched when $\theta = 0°$.

(12 marks)

-END OF QUESTION-

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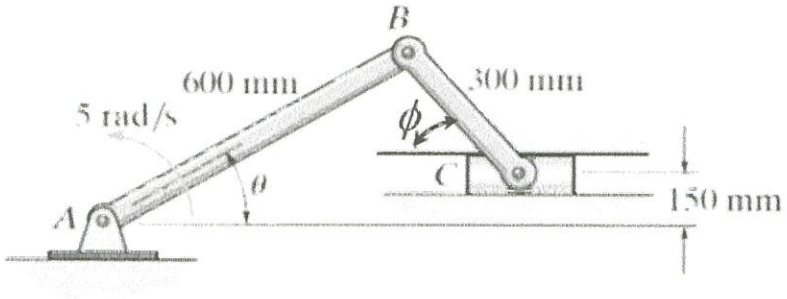

Figure Q3

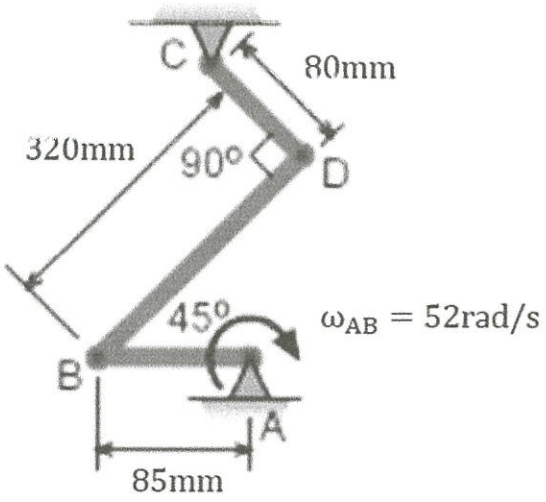

Figure Q4(a)

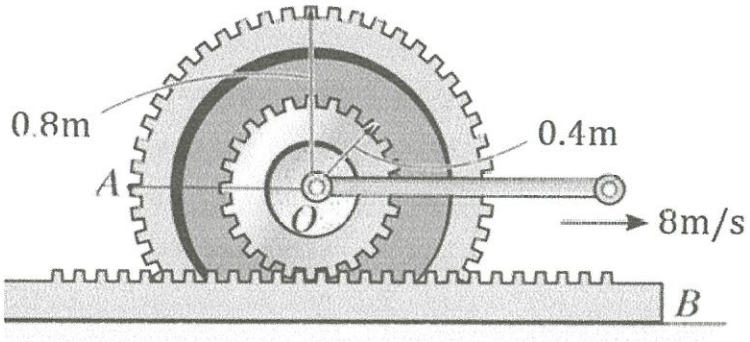

Figure Q4(b)

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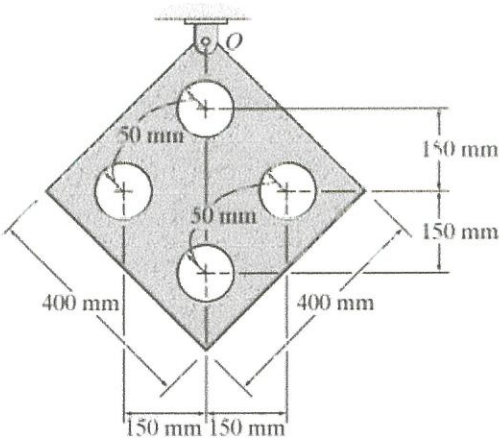

Figure Q5(a)

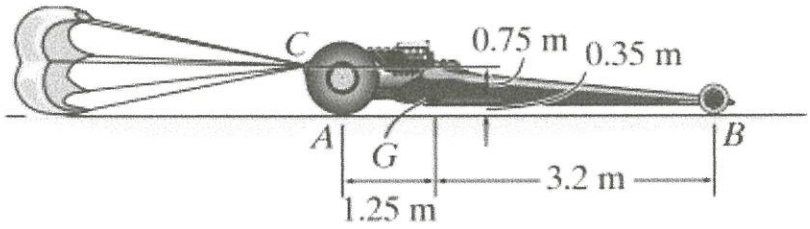

Figure Q5(b)

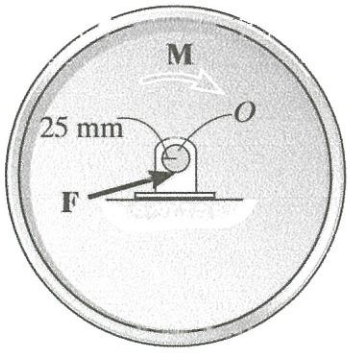

Figure Q5(c)

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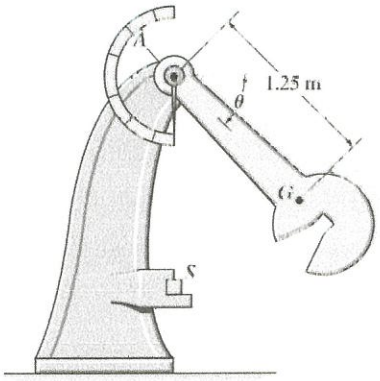

Figure Q6(a)

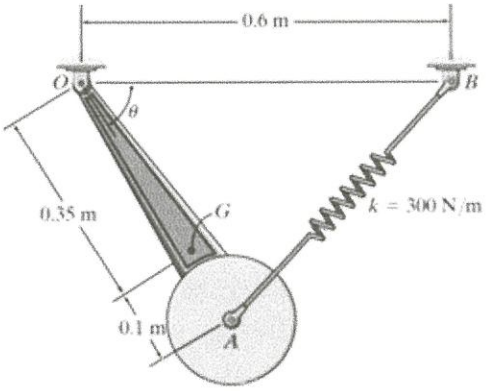

Figure Q6(b)