Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2017/2018

COURSE NAME	:	DYNAMICS
COURSE CODE	:	BDA 20103
PROGRAMME CODE	:	BDD
EXAMINATION DATE	:	DECEMBER 2017/JANUARY 2018
DURATION	:	3 HOURS
INSTRUCTION	:	**PART A (OPTIONAL):** ANSWER **ONE (1)** QUESTION **ONLY** **PART B (COMPULSORY):** ANSWER **ALL** QUESTIONS

THIS QUESTION PAPER CONSISTS OF **TEN (10)** PAGES

PART A (OPTIONAL): ANSWER ONE (1) QUESTION ONLY

Q1 The rod *OA* shown in **Figure Q1** rotates counter clockwise such that it has an angular velocity of 5 rad/s and angular acceleration of 7 rad/s^2 at the instant of angular position of 60°. The collar *B* is pin connected to rod *OA* and slide over rod *CD*. By examining on the above circumstances;

(a) Write down kinematic equations for relative motion analysis of rotating axes that represent the velocity and acceleration of collar *B* as measured by the fixed point *C*.

(3 marks)

(b) Determine the relative velocity and acceleration of collar *B* with respect to fixed point *O*.

(5 marks)

(c) Calculate the velocity of *B* with respect to fixed point *C* as well as angular velocity of rod *CD*.

(6 marks)

(d) Calculate the acceleration of *B* with respect to fixed point *C* as well as its angular acceleration of rod *CD*.

(6 marks)

Q2 **Figure Q2** shows the pendulum which is suspended from point *O* and consists of two thin rods, each having a mass of 8 kg and 5 kg respectively. A rectangular thin plate with the hollow section is welded at one end of horizontal rod and another square plate at the other end. The rectangular thin plate has a mass of 10 kg/m^2 while square thin plate has a mass of 3 kg/m^2. By examining on the above situation;

(a) Calculate moment of inertia of the pendulum about point *O*.

(12 marks)

(b) Determine the location of $\bar{y}$ of the mass center, *G* of the pendulum.

(4 marks)

(c) Determine the moment of inertia I_G.

(4 marks)

PART B (COMPULSORY): ANSWER ALL QUESTIONS

Q3 (a) Consider the trajectory of the cannonball shown in **Figure Q3(a).** Take up as positive and down as negative. Determine,

i. Where is the magnitude of the vertical-velocity component largest?
ii. Where is the magnitude of the horizontal-velocity component largest?
iii. Where is the vertical-velocity smallest?
iv. Where is the magnitude of the acceleration smallest?

(4 marks)

(b) At the instant shown in **Figure Q3(b)** the car at *A* is travelling at 10 m/s around the curve while increasing its speed at 5 m/s². The car at *B* is travelling at 18.5 m/s along the straightaway and increasing its speed at 2 m/s².

i. Write the vector for relative velocity and acceleration of *A* with respect to *B*, ($v_{A/B}$, $a_{A/B}$)

(4 marks)

ii. Calculate the relative velocity and acceleration of *A* with respect to *B*, ($v_{A/B}$, $a_{A/B}$)

(8 marks)

iii. Sketch the magnitude and direction for $v_{A/B}$.

(4 marks)

Q4 A 20g bullet is fired into a 4 kg wooden block at rest position as shown in **Figure Q4**. The force was acting to the bullet 950N in time period of 0.015s. The wooden block has been hit by the bullet and was embedded in the wooden block. Neglect the coefficient of friction between the wooden block and inclined surface.

(a) Calculate the velocity of the bullet when it was fired.

(4 marks)

(b) Calculate the velocity of the wooden block after has been heated by the bullet.

(8 marks)

(c) Calculate the maximum distance cleared by the wooden block and bullet slide up the inclined surface.

(8 marks)

Q5 (a) List and explain the types of rigid body plane motion.

(5 marks)

(b) **Figure Q5(b)** shows the belt sander is initially at rest condition. If the driving drum *B* has a constant angular acceleration of 120 rad/s² counter clockwise,, determine the magnitude of the acceleration of the belt at point *C* when time, $t = 2$s.

(5 marks)

(c) In **Figure Q5(c),** ring *C* has an inside radius of 55 mm and an outside radius of 60 mm and is positioned between two wheels *A* and *B*, each of 24 mm outside radius. Knowing that wheel *A* rotates with a constant angular velocity of 300 rpm and that no slipping occurs,

i. Calculate the angular velocity of the ring *C* and wheel *B*.

(5 marks)

ii. Calculate the normal acceleration of the Points *1* and *2* which are in contact with *C*.

(5 marks)

Q6 **Figure Q6** shows a spring-toggle mechanism. A couple $M = 12$ Nm is applied at point C to the mechanism, which is released from rest in the position $\theta = 45°$. In this position the spring is stretched 150 mm. Suppose the motion is in the vertical plane, and friction is negligible, while the spring stiffness is 140 N/m, bar AB has a mass of 3 kg and BC a mass of 6 kg,

(a) Determine the total kinetic energy, ΔT.

(5 marks)

(b) Determine the total gravitational potential energy, ΔVg.

(5 marks)

(c) Calculate the total elastic potential energy, ΔVe.

(5 marks)

(d) Calculate the angular velocity, ω of BC as it crosses the position $\theta = 0$.

(5 marks)

-END OF QUESTIONS-

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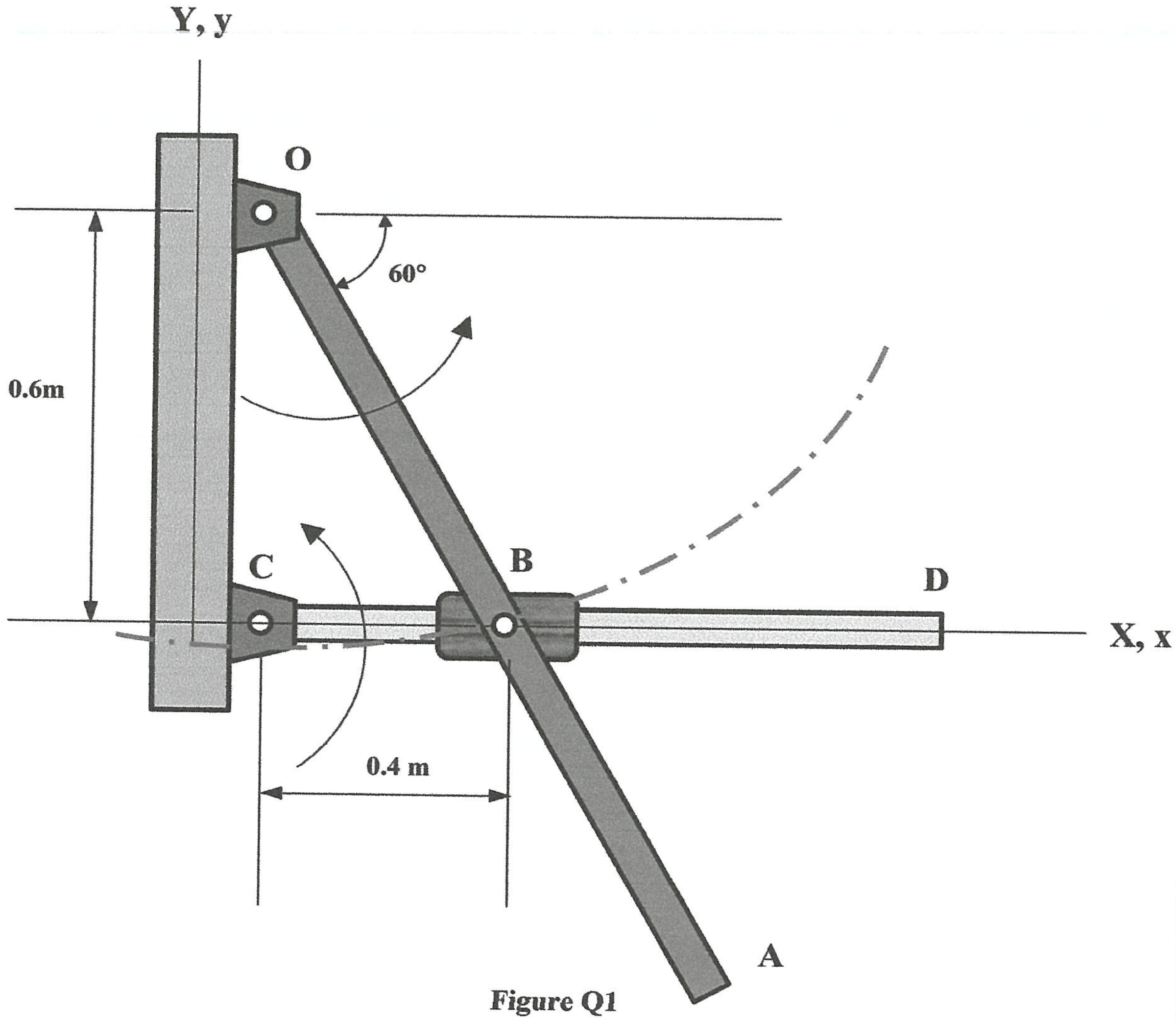

Figure Q1

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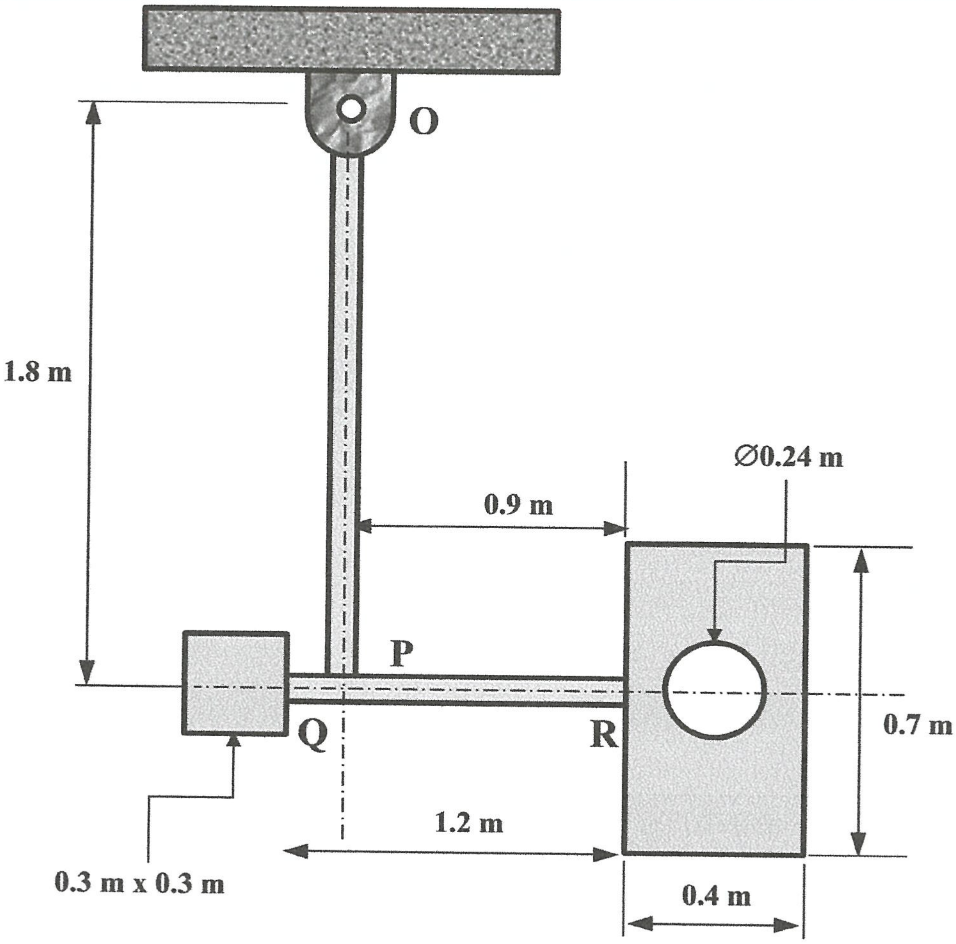

Figure Q2

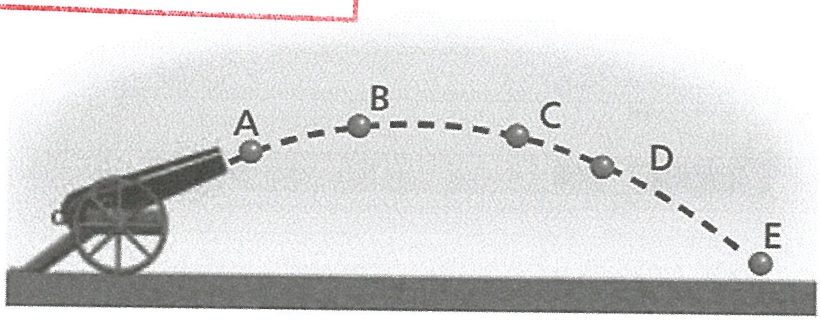

Figure Q3(a)

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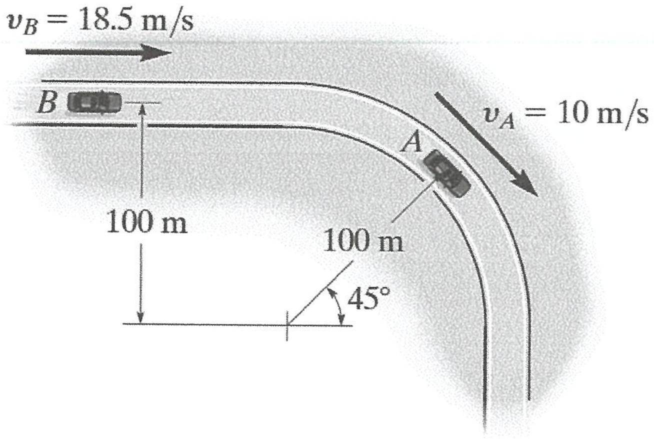

Figure Q3(b)

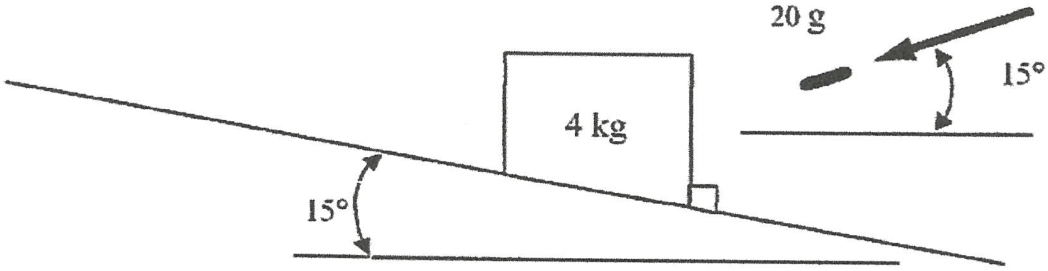

Figure Q4

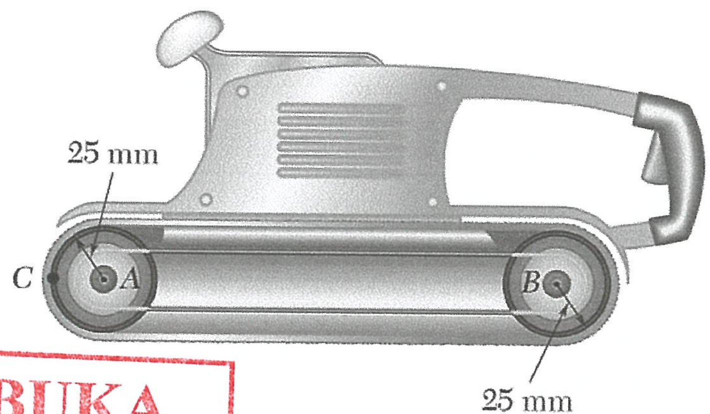

Figure Q5(b)

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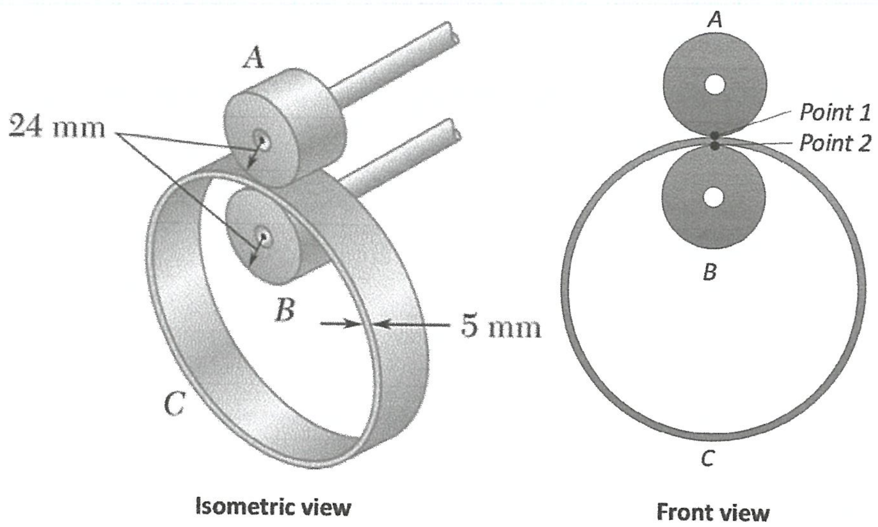

Figure Q5(c)

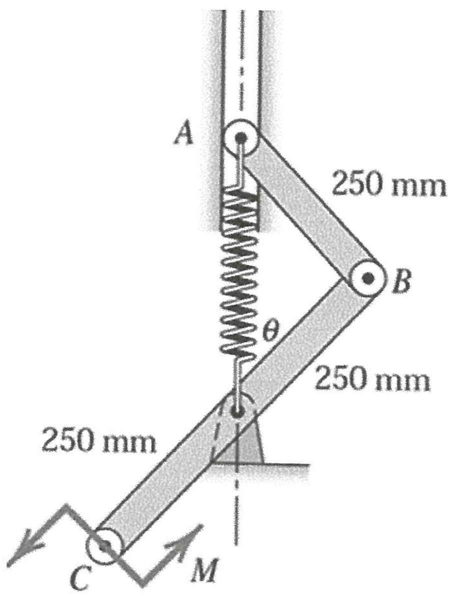

Figure Q6

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KINEMATICS

Particle Rectilinear Motion

Variable a	*Constant* $a = a_c$
$a = dv/dt$	$v = v_0 + a_c t$
$v = ds/dt$	$s = s_0 + v_0 t + 0.5 a_c t^2$
$a\,ds = v\,dv$	$v^2 = v_0^2 + 2a_c(s - s_0)$

Particle Curvilinear Motion

x, y, z Coordinates		*r, θ, z Coordinates*	
$v_x = \dot{x}$	$a_x = \ddot{x}$	$v_r = \dot{r}$	$a_r = \ddot{r} - r\dot{\theta}^2$
$v_y = \dot{y}$	$a_y = \ddot{y}$	$v_\theta = r\dot{\theta}$	$a_\theta = r\ddot{\theta} + 2\dot{r}\dot{\theta}$
$v_z = \dot{z}$	$a_z = \ddot{z}$	$v_z = \dot{z}$	$a_z = \ddot{z}$

n, t, b Coordinates

$v = \dot{s}$ $\quad a_t = \dot{v} = v\dfrac{dv}{ds}$

$a_n = \dfrac{v^2}{\rho} \quad \rho = \dfrac{\left[1 + (dy/dx)^2\right]^{3/2}}{\left|d^2y/dx^2\right|}$

Relative Motion

$v_B = v_A + v_{B/A} \qquad a_B = a_A + a_{B/A}$

Rigid Body Motion About a Fixed Axis

Variable a	*Constant* $a = a_c$
$\alpha = d\omega/dt$	$\omega = \omega_0 + \alpha_c t$
$\omega = d\theta/dt$	$\theta = \theta_0 + \theta_0 t + 0.5\alpha_c t^2$
$\omega\,d\omega = \alpha\,d\theta$	$\omega^2 = \omega_0^2 + 2\alpha_c(\theta - \theta_0)$

For Point P

$s = \theta r \qquad \upsilon = \omega r \qquad a_t = \alpha r \qquad a_n = \omega^2 r$

Relative General Plane Motion – Translating Axis

$v_B = v_A + v_{B/A(pin)} \qquad a_B = a_A + a_{B/A(pin)}$

Relative General Plane Motion – Trans. & Rot. Axis

$v_B = v_A + \Omega \times r_{B/A} + (v_{B/A})_{xyz}$

$a_B = a_A + \dot{\Omega} \times r_{B/A} + \Omega \times (\Omega \times r_{B/A}) + 2\Omega \times (v_{B/A})_{xyz} \times (a_{B/A})_{xyz}$

KINETICS

Mass Moment of Inertia $\quad I = \int r^2 dm$

Parallel-Axis Theorem $\quad I = I_G + md^2$

Radius of Gyration $\quad k = \sqrt{I/m}$

Equations of Motion

Particle	$\sum F = ma$
Rigid Body (Plane Motion)	$\sum F_x = m(a_G)_x \quad \sum F_y = m(a_G)_y$ $\sum M_G = I_G \alpha$ or $\sum M_P = \sum(\mu_k)_P$

Principle of Work and Energy : $T_1 + U_{1-2} = T_2$

Kinetic Energy

Particle	$T = (1/2)mv^2$
Rigid Body (Plane Motion)	$T = (1/2)mv_G^2 + (1/2)I_G\omega^2$

Work

Variable force	$U_F = \int F\cos\theta\, ds$
Constant force	$U_F = (F_c \cos\theta)\Delta s$
Weight	$U_W = -W\,\Delta y$
Spring	$U_s = -\left(0.5ks_2^2 - 0.5ks_1^2\right)$
Couple moment	$U_M = M\,\Delta\theta$

Power and Efficiency

$P = dU/dt = F.v \qquad \varepsilon = P_{out}/P_{in} = U_{out}/U_{in}$

Conservation of Energy Theorem

$T_1 + V_1 = T_2 + V_2$

Potential Energy

$V = V_g + V_e$ where $V_g = \pm Wy, V_e = +0.5ks^2$

Principle of Linear Impulse and Momentum

Particle	$mv_1 + \sum\int F dt = mv_2$
Rigid Body	$m(v_G)_1 + \sum\int F dt = m(v_G)_2$

Conservation of Linear Momentum

$\sum(\text{syst. } mv)_1 = \sum(\text{syst. } mv)_2$

Coefficient of Restitution $\quad e = \dfrac{(v_B)_2 - (v_A)_2}{(v_A)_1 - (v_B)_1}$

Principle of Angular Impulse and Momentum

Particle $\quad (H_O)_1 + \sum\int M_O dt = (H_O)_2$
where $H_O = (d)(mv)$

Rigid Body (Plane motion) $\quad (H_G)_1 + \sum\int M_G dt = (H_G)_2$
where $H_G = I_G\omega$
$(H_O)_1 + \sum\int M_O dt = (H_O)_2$
where $H_O = I_O\omega$

Conservation of Angular Momentum

$\sum(\text{syst. } H)_1 = \sum(\text{syst. } H)_2$

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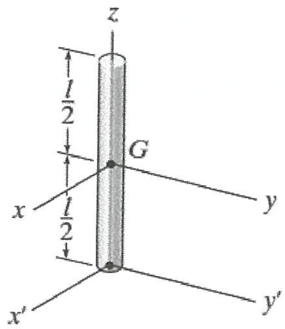
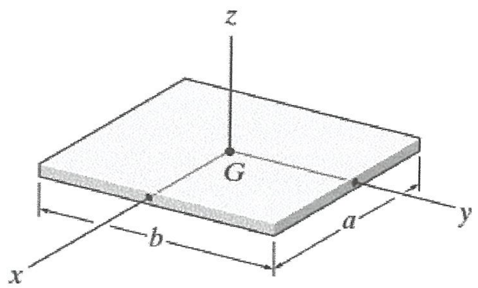


Slender Rod

$$I_{xx} = I_{yy} = \frac{1}{12}ml^2$$

$$I_{x'x'} = I_{y'y'} = \frac{1}{3}ml^2$$

$$I_{zz} = 0$$

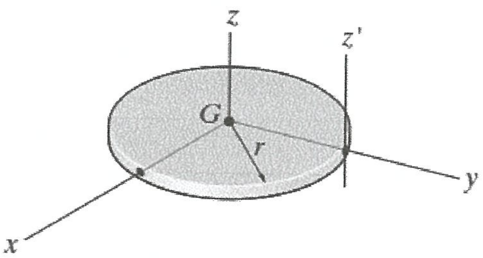


Thin plate

$$I_{xx} = \frac{1}{12}mb^2$$

$$I_{yy} = \frac{1}{12}ma^2$$

$$I_{zz} = \frac{1}{12}m(a^2 + b^2)$$



Thin Circular disk

$$I_{xx} = I_{yy} = \frac{1}{4}mr^2$$

$$I_{zz} = \frac{1}{2}mr^2$$

$$I_{z'z'} = \frac{3}{2}mr^2$$