UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2011/2012

COURSE NAME	:	DYNAMICS
COURSE CODE	:	BDA 20103/BDA 2013
PROGRAMME	:	2 BDD
EXAMINATION DATE	:	JANUARY 2012
DURATION	:	3 HOURS
INSTRUCTION	:	**PART A :** ANSWER **ALL** THE QUESTIONS **PART B :** ANSWER **THREE (3)** QUESTIONS ONLY

THIS EXAMINATION PAPER CONTAIN (9) PAGES

PART A (COMPULSORY) :

Q1 **FIGURE Q1** shows a 0.02 kg bullet which is travelling at the speed of $380 m/s$. The bullet strikes the 6 kg wooden block and then exit the other side of the block at $12 m/s$. The coefficient of kinetic friction between the block and surface is $\mu_K = 0.6$.

(a) Determine the speed of the block just after the bullet exit the block.

(8 marks)

(b) Find the average normal force on the block if the bullet passes through it in $1.5\, ms$.

(8 marks)

(c) Calculate the time the block slides before it stops.

(4 marks)

Q2 Two smooth disks A and B, having a mass of 1 kg and 2 kg, respectively, collide with the velocities shown in **FIGURE Q2**. The coefficient of restitution for the disks is $e = 0.75$.

(a) Resolve each of the initial velocities into x and y components.

(4 marks)

(b) Momentum of the system is conserved along the line of impact. Write the equation of momentum for the system.

(6 marks)

(c) Write the coefficient of restitution that relate the relative velocities of the disks along the line of impact, just before and after collision.

(2 marks)

(d) Determine the x and y components of the final velocity of each disk just after collision.

(8 marks)

PART B :

Q3 (a) Explain the **three** (3) different types of rigid-body motions. Provide **one** (1) example for each type of motion.

(6 marks)

(b) Gear A of the winch turns gear B, raising the hook H as in **FIGURE Q3(b)**. Gear A starts from rest at time $t = 0$ and its clockwise angular acceleration (in rad/s^2) is given as a function of time by $\alpha_A = 0.2t$.

(i) What is the upward velocity of the hook at $t = 10$ s?

(ii) Determine how high the hook rises in $10s$ starting from rest.

(iii) Let P_A be the point of gear A that is in contact with gear B at $t = 10$ s. Determine the magnitude of acceleration, P_A at that instant.

(14 marks)

Q4 (a) The shaper mechanism in **FIGURE Q4(a)** is designed to give a slow cutting stroke and a quick return to a blade attached to the slider at C. If link AB is rotating at angular velocity $\omega = 4\ rad/s$,

(i) determine the velocity of the slider block C at this instant using vector analysis, or scalar analysis.

(ii) determine the velocity of the slider block C at this instant using the method of instantaneous center of zero velocity.

(10 marks)

(b) At a given instant the slider block B is moving to the right with the motion shown in **FIGURE Q4(b)**. Determine the angular acceleration of link AB and the acceleration of point A at this instant.

(10 marks)

Q5 A 10 kg block B is suspended by a cord which passes around a frictionless pulley of negligible mass at D and is wrapped around a 100 kg wheel A as shown in **FIGURE Q5**. The wheel A has a central radius of gyration $k_O = 0.5\,m$. If the wheel A rolls without slipping

(a) Draw the free body diagram of the forces and motion of the wheel A and block B.

(2 marks)

(b) Write the equations of motion of the wheel A and block B.

(3 marks)

(c) Determine the acceleration of block B, $a_B\ m/s^2$ when the system is released from rest.

(5 marks)

(d) Determine the acceleration of block A, $a_A\ m/s^2$.

(5 marks)

(e) Determine the tension of the cord on the wheel A, T_A.

(5 marks)

Q6 The slender bar AB as shown in **FIGURE Q6** of mass 15 kg rotates at A with angular velocity $0.1\,rad/s$ counterclockwise when it is at the horizontal position. The unstretched length of the spring is 1.5 m, and the spring constant is $k = 50\ N/m$.

(a) Show that the mass moment of inertia, I_A and I_G of the homogeneous slender bar of mass, m and length, l are $I_A = (1/3)ml^2$ and $I_G = (1/12)ml^2$, respectively (Use the mass element, $d_m = \rho\, dx$ where ρ is the mass per unit length).

(5 marks)

(b) Determine the change in the potential energy due to gravity, ΔV_g.

(5 marks)

(c) Determine the change in the potential energy due to spring stiffness, ΔV_e.

(5 marks)

(d) Determine the angular velocity of the bar, $\omega\ rad/s$ when it is in the position shown.

(5 marks)

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FIGURE Q1

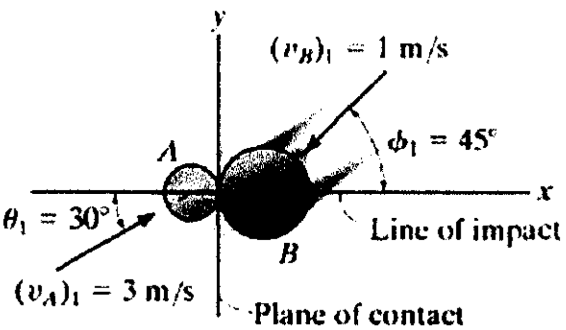

FIGURE Q2

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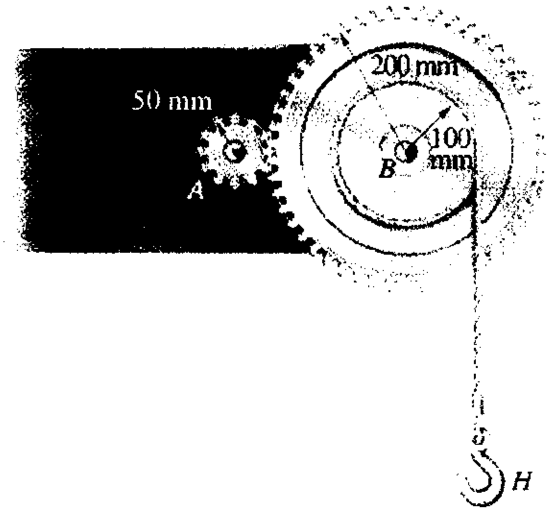

FIGURE Q3(b)

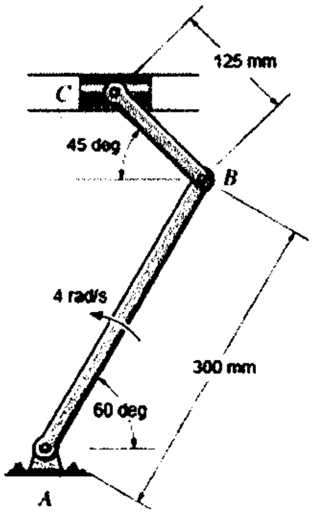

FIGURE Q4 (a)

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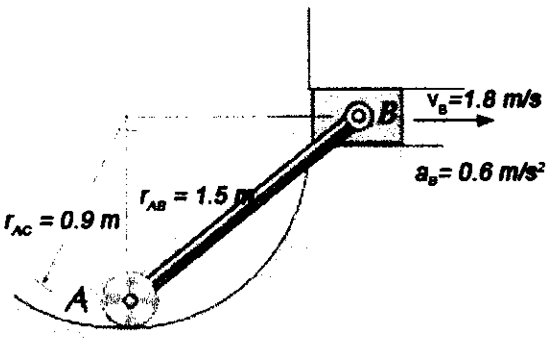

FIGURE Q4 (b)

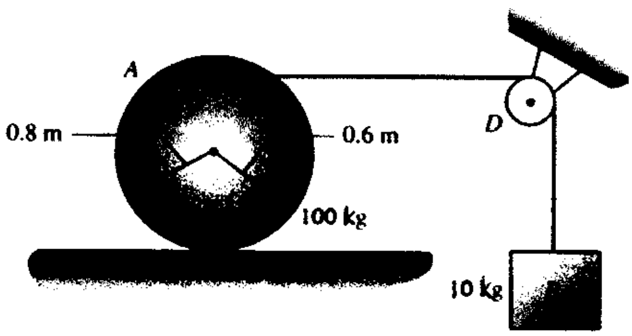

FIGURE Q5

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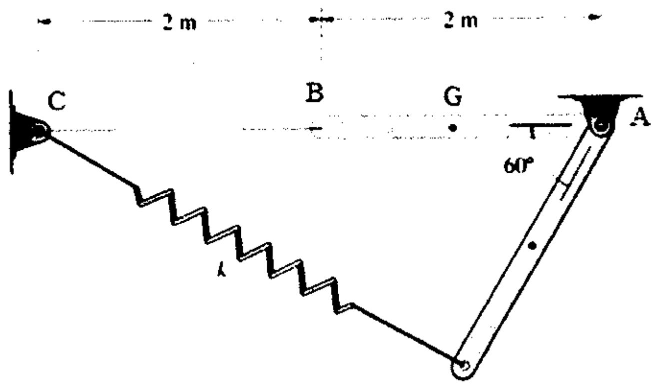

FIGURE Q6

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Fundamental Equations of Dynamics :

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

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

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 $I = \int r^2 dm$

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

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

Equations of Motion

Particle	$\sum F = ma$
Rigid Body (Plane Motion)	$\sum F_x = m(a_G)_x \quad \sum F_y = m(a_G)_y$ $\sum M_G = I_G a$ 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

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

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 $e = \dfrac{(v_B)_2 - (v_A)_2}{(v_A)_1 - (v_B)_1}$

Principle of Angular Impulse and Momentum

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

Rigid Body (Plane motion) $(H_G)_1 + \sum\int M_G dt = (H_G)_2$
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

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