Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER 1
SESSION 2019/2020

COURSE NAME	:	DYNAMICS
COURSE CODE	:	BDA 20103
PROGRAMME	:	BDD
EXAMINATION DATE	:	DECEMBER 2019 / JANUARY 2020
DURATION	:	3 HOURS
INSTRUCTION	:	PART A: ANSWER **ALL** QUESTIONS PART B: ANSWER **THREE (3)** QUESTIONS **ONLY**

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

PART A (COMPULSORY):
Answer **ALL** questions.

Q1. (a) The flight path of the passenger hot air balloon as it takes off from point A is defined by $x = (1.5t^2)$ m, where t is in seconds as shown in **Figure Q1 (a)**. The equation of the path is $y = \frac{1}{15}x^2 + 4$.

(i) Find the distance of hot air balloon from point A when t = 4s.
(2 marks)

(ii) Determine the magnitude and direction of the velocity when t= 4s.
(4 marks)

(iii) Calculate the magnitude and direction of the acceleration when t = 4s.
(4 marks)

(b) **Figure Q1 (b)** shows fighter jet plane P is flying along a straight path, while aerobatic plane Q is flying along a circular path having a radius of curvature of 300 km. Both plane P and Q are flying at the same altitude. At the instant shown, plane P fly at the velocity of 950 km/hr while plane Q fly at the velocity of 550 km/hr. Also at this instant, plane P has an acceleration of 100 km/hr^2 and plane Q has a deceleration of 250 km/hr^2. The angle between straight path of plane P and the horizontal line is $\theta = 60°$.

(i) Calculate the magnitude and direction of velocity of plane Q as measured by the pilot of plane P.
(5 marks)

(ii) Determine the magnitude and direction of acceleration of plane Q with respect to plane P.
(5 marks)

Q2. **Figure Q2** shows a system consists of 45 kg block A, 5 kg cylinder B and 11 kg block C. Suppose block A pulls the system down a smooth ramp, and the coefficient of kinetic friction between the horizontal surface and block C $(\mu k)_c$ is 0.2;

(a) Draw the Kinetic Diagram of block A, cylinder B and block C.
(12 marks)

(b) Determine the acceleration of the system and the tension in each cable.
(8 marks)

PART B (OPTIONAL):
Answer **THREE (3)** questions **ONLY**.

Q3. (a) Explain the types of rigid body plane motion.

(6 marks)

(b) In **Figure Q3(b)**, a bowling ball is cast on the "alley" with a backspin of $\omega = 12$ rad/s while its center O has a forward velocity of $v_o = 10$ m/s. Determine the velocity of the contact point A in contact with the alley.

(4 marks)

(c) In **Figure Q3(c)**, the link AB has an angular velocity of $\omega = 3$ rad/s and $\theta = 45°$.

(i) Sketch the kinematic diagram of link AB and BC.
(ii) Determine the velocity of block C.
(iii) Determine the angular velocity of link BC.

(10 marks)

Q4. In **Figure Q4**, boat A travels with a speed of 15 m/s, which is decelerate at 3 m/s^2, while boat B travels with a speed of 10 m/s, which is accelerate at 2 m/s^2.

(a) Draw the kinematic diagram of boat A and boat B.

(4 marks)

(b) Calculate the velocity of boat A with respect to boat B using method of relative motion analysis of rotating axes.

(6 marks)

(c) Calculate the acceleration of boat A with respect to boat B using method of relative motion analysis of rotating axes.

(10 marks)

Q5. A structure consist of a uniform 5 kg thin plate with a dimensions of 300 mm × 200 mm and a 2 kg slender rod within 500 mm length is attached to pivot O. It is hold at horizontal position as illustrated in **Figure Q5**.

(a) Calculate moment of inertia of both slender bar and thin plate about its center of mass respectively.

(2 marks)

(b) Find center of mass of the structure, seen in x-y coordinate systems, with the origin is O.

(5 marks)

(c) Find the mass moment of inertia of the structure about the axis of rotation, O.

(5 marks)

(d) If the structure is release from its horizontal position with an initial rotation of ω_o = 0.1 rads^{-1}, determine the angular velocity, ω_1 of the structure when the slender bar is exactly in a vertical position to the bottom. Note: Moment of inertia of slender bar about its center of mass, $^1/_{12}\, mL^2$; Moment of inertia of thin plate about its center of mass, $^1/_{12}\, m(b^2 - h^2)$.

(8 marks)

Q6 **Figure Q6** shows a manual winch rotates about a fixed axis A as to load goods at raises floor. The wire rope is encircle to a 5 kg circular cylinder with a radius of 150 mm, while 4 unit of 200 mm length spokes are made of slender rod having a weight of 1 kg individually. A workers has coincidently drop the 20 kg crate C to the datum at 10 m height due to fatigue at work. Neglect weight of pulley B.

(a) Calculate mass moment of inertia of the manual winch about its rotational axis at A.

(6 marks)

(b) Determine crate's velocity just before its reach datum.

(14 marks)

Note:
Moment of inertia of circular cylinder slender bar about its center of mass, $^{1}/_{2}\ mr^{2}$;
Moment of inertia of slender bar about its center of mass, $^{1}/_{12}\ mL^{2}$.

-END OF QUESTION-

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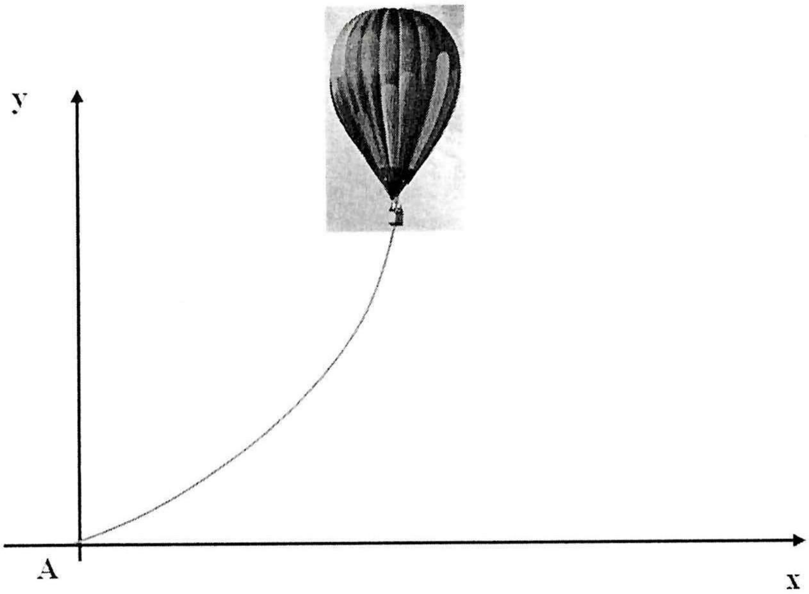

Figure Q1 (a)

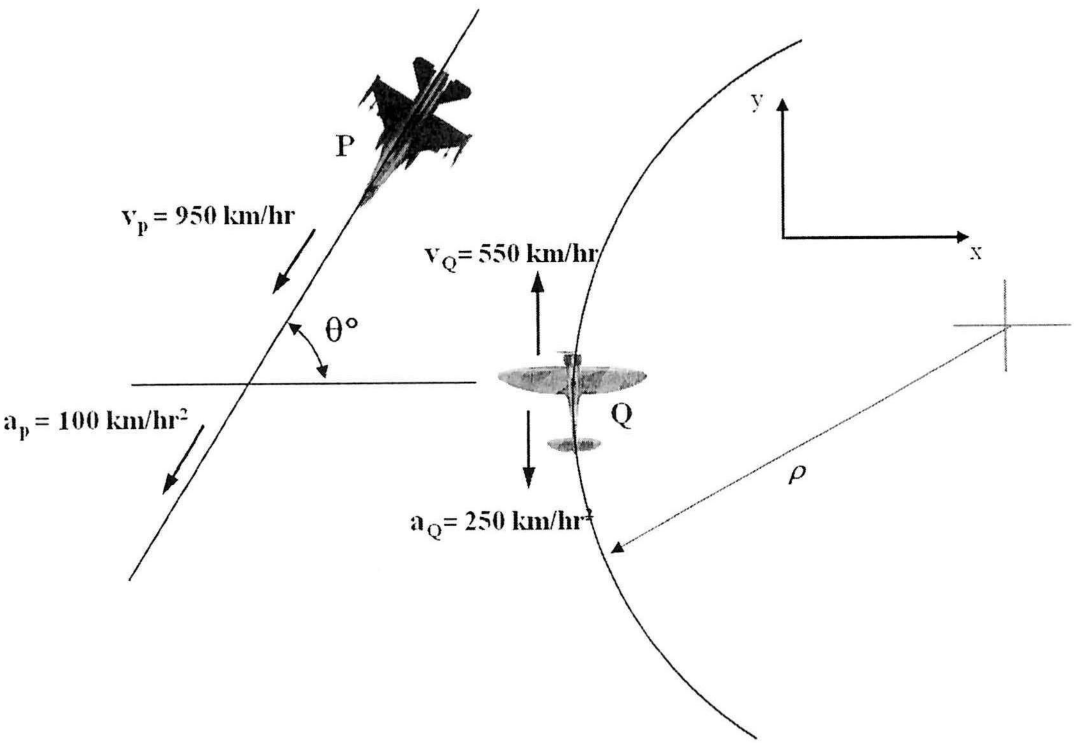

Figure Q1 (b)

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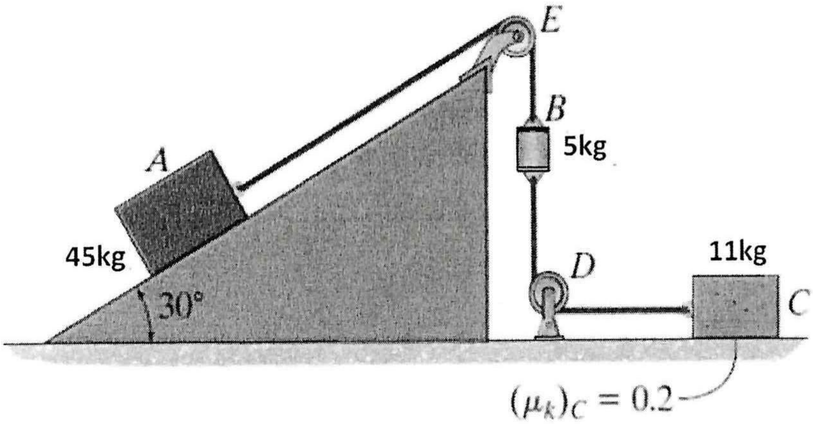

Figure Q2

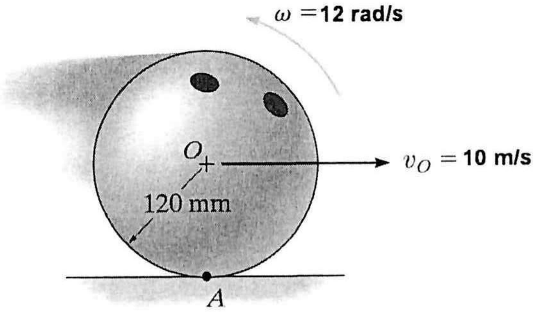

Figure Q3(b)

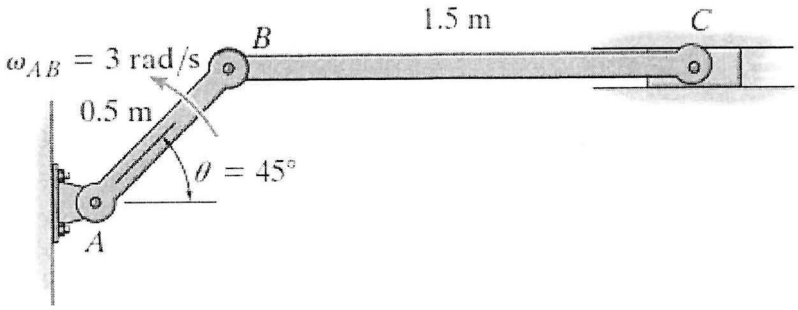

Figure Q3(c)

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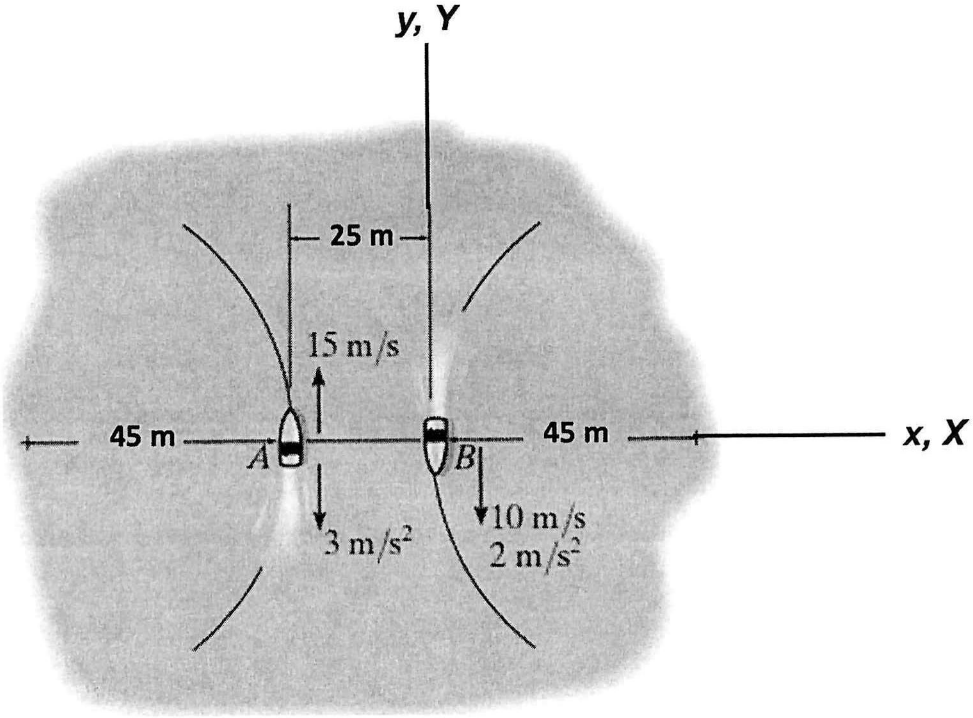

Figure Q4

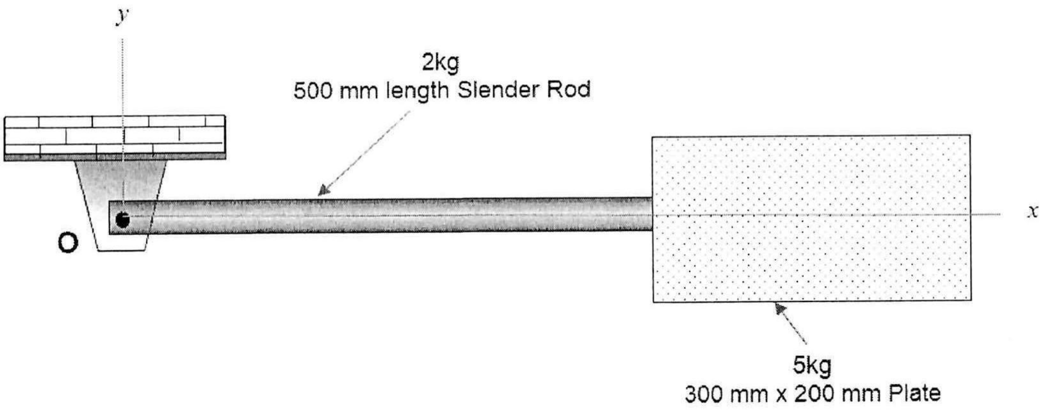

Figure Q5

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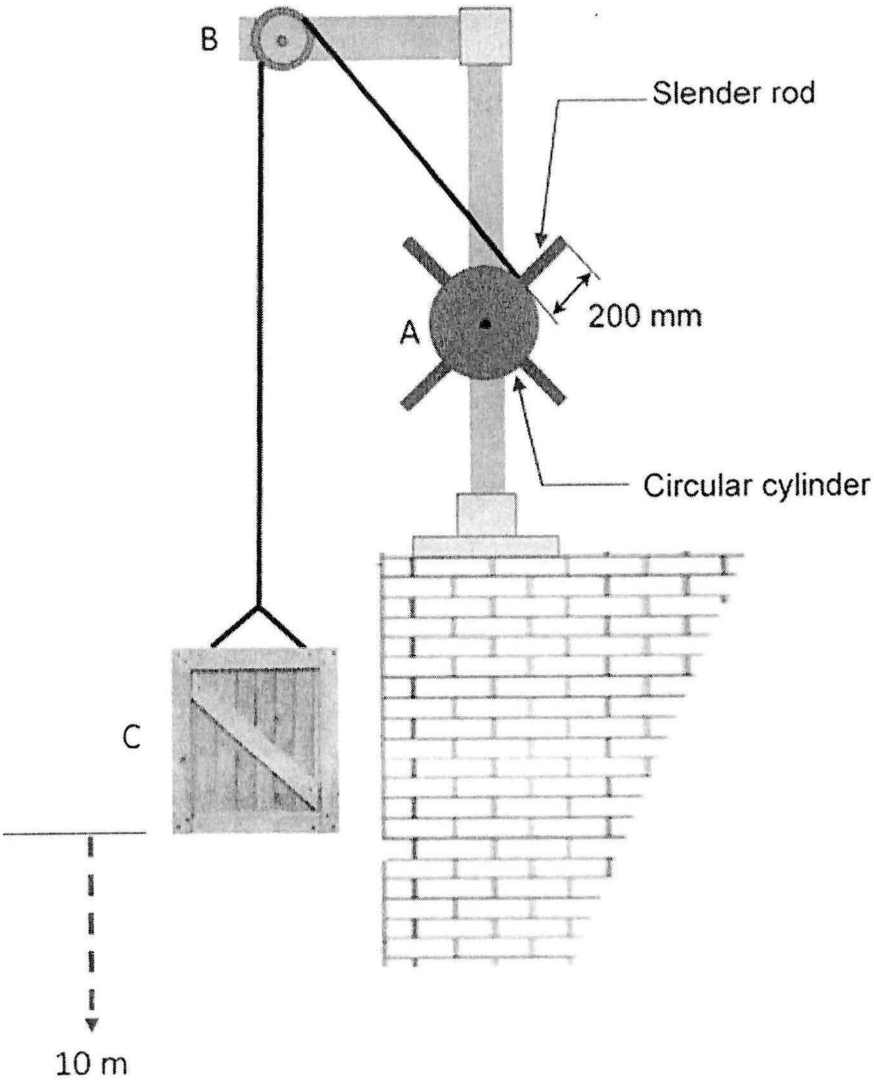

Figure Q6

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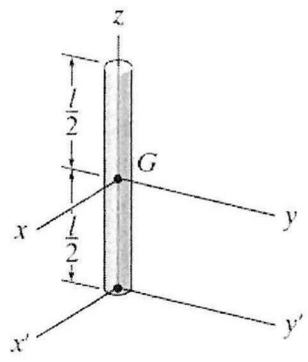
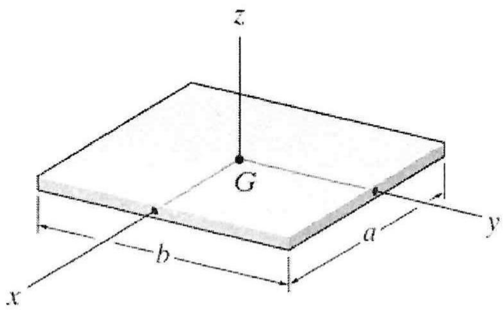


Slender Rod

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

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

$$I_{zz} = 0$$

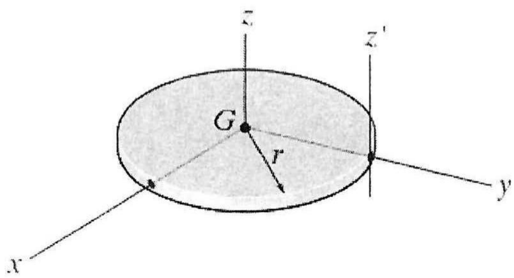


Thin plate

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

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

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



Thin Circular disk

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

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

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

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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

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

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

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)	$\sum F_x = m(a_G)_x \quad \sum F_y = m(a_G)_y$ $\sum M_G = I_G a$ 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	$U_s = -(0.5ks_2^2 - 0.5ks_1^2)$
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 $\quad e = \dfrac{(v_B)_2 - (v_A)_2}{(v_A)_1 - (v_B)_1}$

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