UNIVERSITI SAINS MALAYSIA

Peperiksaan Semester Kedua
Sidang Akademik 2004/2005

Mac 2005

EMM 212/4 – DINAMIK & MEKANISMA

Masa : 3 jam

ARAHAN KEPADA CALON :

Sila pastikan bahawa kertas soalan ini mengandungi **LAPAN (8)** mukasurat dan **ENAM (6)** soalan serta **SATU (1)** lampiran yang bercetak sebelum anda memulakan peperiksaan.

Sila jawab **LIMA (5)** soalan sahaja.

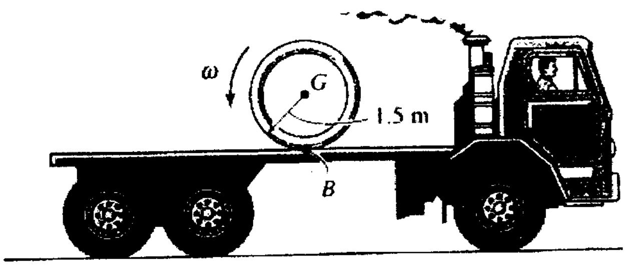
Lampiran A : Formula Asas Dinamik

Pelajar dibenarkan menjawab semua soalan dalam **Bahasa Inggeris** ATAU **Bahasa Malaysia** ATAU kombinasi kedua-duanya.

Setiap soalan mestilah dimulakan pada mukasurat yang baru.

S1. [a] Pada ketika yang ditunjukkan pada Rajah S1[a] trak yang membawa paip sedang bergerak ke kanan pada halaju 8t m/s. Paip yang dibawa oleh trak tersebut berguling tanpa gelincir pada titik B lawan arah jam dengan halaju putaran $\omega = 2t$ rad/s. Tentukan halaju pusat paip, G dalam bentuk fungsi masa, t.

The truck as shown in Figure Q1[a] is traveling to the right at a velocity of 8t m/s, while the pipe is rolling counterclockwise at an angular velocity of $\omega = 2t$ rad/s without slipping at B. Determine the velocity of the pipe's center G as a function of time.



Rajah S1[a]
Figure Q1[a]

(40 markah)

[b] Rajah S1[b] menunjukkan mekanisma penyambung 4-bar. Pada ketika yang ditunjukkan lengan AB diputarkan dengan halaju sudut ω_{AB} rad/s arah lawan jam seperti yang ditunjukkan.

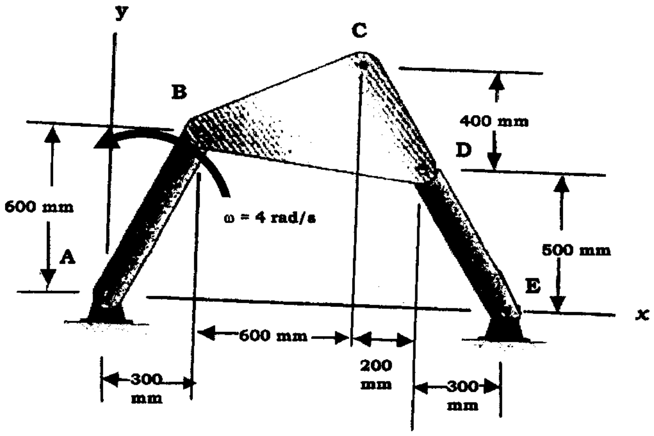
Tentukan halaju, v_C pada :

i] titik B
ii] titik D
iii] titik C

Bar AB in Figure Q1[b] rotates at $\omega = 4$ rad/s in the counterclockwise direction.

Determine the velocity of :

i] point B
ii] point D
iii] point C



Rajah S1[b]
Figure Q1[b]

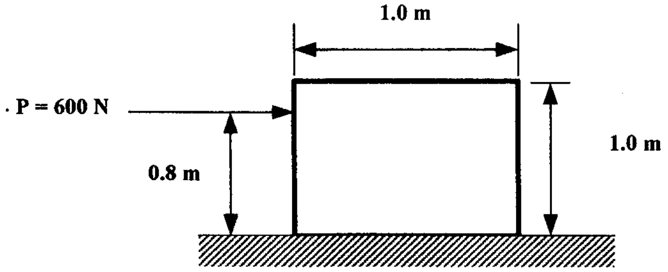
(60 markah)

S2. [a] Rajah S2[a] menunjukkan kotak 50 kg berjisim seragam yang terletak pada permukaan lantai yang mempunyai pekali geseran kinetik, $\mu_k = 0.2$.

i] Lukiskan rajah badan bebas dan rajah kinetik bagi kotak tersebut.
ii] Tentukan pecutan bagi kotak jika daya P = 600 N dikenakan pada kotak.

A uniform 50 kg crate as shown in Figure Q2[a] rests on the horizontal surface for which the coefficient of kinetic friction is $\mu_k = 0.2$.

i] Draw a free body diagram and kinetic diagrams for the 50 kg crate.
ii] Determine the crate's acceleration if a force of P = 600 N is applied to the crate.

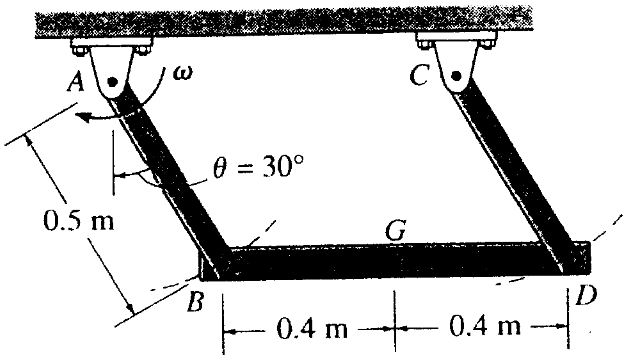


Rajah S2[a]
Figure Q2[a]

(50 markah)

[b] **Palang berjisim 100kg pada Rajah S2[b] disokong oleh dua rod yang jisimnya boleh diabaikan. Tentukan daya yang dihasilkan bagi setiap rod pada ketika rod berada pada sudut θ = 30° dan kedua-duanya berputar pada halaju sudut, ω = 6 rad/s.**

The 100 kg beam BD shown in Figure Q2[b] is supported by two rods having negligible mass. Determine the force created in each rod if at the instant θ = 30° in which the rods are both rotating with an angular velocity of ω = 6 rad/s.

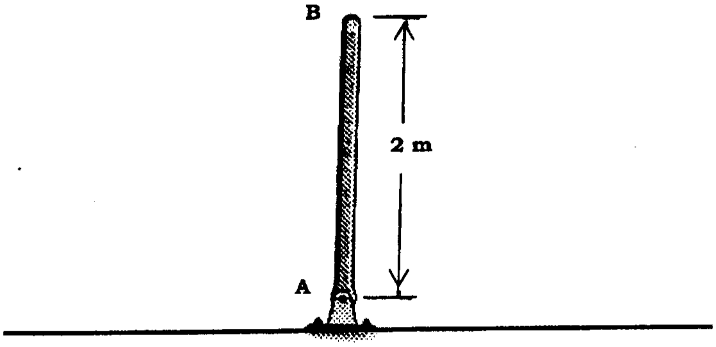


Rajah S2[b]
Figure Q2[b]

(50 markah)

S3. [a] **Palang berjisim 50 kg pada Rajah S3[a] dilepaskan dari keadaan rehat. Dengan menggunakan Prinsip Kerja dan Tenaga, tentukan laju hujung B sebaik sahaja palang menghempas tanah.**

The 50 kg bar as shown in Figure Q3[a] falls from rest. By using the Principle of Work and Energy, determine the speed of its end B just before it strikes the ground.

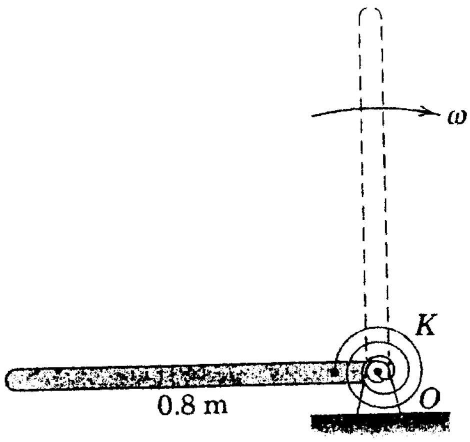


Rajah S3[a]
Figure Q3[a]

(40 markah)

[b] Palang langsing yang berjisim 6 kg diikat pada titik O secara menegak seperti pada Rajah S3[b]. Kekakuan pegas kilasan, K, ialah 30 N.m/rad. Jika palang itu dilepaskan pada keadaan rehat dari kedudukan mengufuk, tentukan halaju putaran, ω apabila palang melepasi kedudukan menegak. (Abaikan geseran).

The torsional spring has a stiffness of 30 N.m/rad and is undeflected when the 6 kg uniform slender bar is in the upright position. If the bar is released from rest in the horizontal position shown in Figure Q3[b], determine its angular velocity ω as it passes the vertical position. Friction is negligible.



Rajah S3[b]
Figure Q3[b]

(60 markah)

S4. [a] Terangkan dengan ringkas klasifikasi untuk giar.
Classify the gears with brief explanation.

(25 markah)

[b] Lakarkan jenis-jenis rangkaian gear berikut dan terbitkan persamaan untuk nisbah halaju giar masukan dan gear keluaran.

i] susunan giar ringkas
ii] susunan giar majmuk
iii] susunan giar balikan

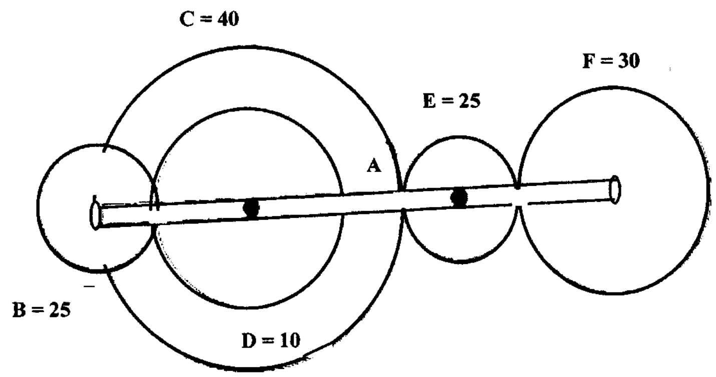
Sketch the following types of gear trains and derive an expression of velocity ratios between input gear and output gear.

i] simple gear train.
ii] compound gear train.
iii] reverted gear train.

(25 markah)

[c] **Rajah S4[c] menunjukkan susunan rangkaian giar kisar. Roda E dimatikan manakala roda C dan D adalah giar majmuk dan dipasang pada pin. Jika lengan A berputar dalam arah ikut jam sebanyak 120 p.s.m., tentukan kelajuan dan arah pusingan roda B dan F.**

Figure Q4[c] shows an epicylic gear train arrangement. Wheel E is fixed and wheels C and D are compound gears which is mounted on the pin. If the arm A is rotating in the clockwise direction with a speed of 120 rpm determine the speed and directions of rotation of wheels B and F.



Rajah S4[c]
Figure Q4[c]

(50 markah)

S5. [a] **Terangkan dengan ringkas kesan ketidak imbangan jisim berputar.**
Explain briefly the effect of an unbalance rotating masses.

(15 markah)

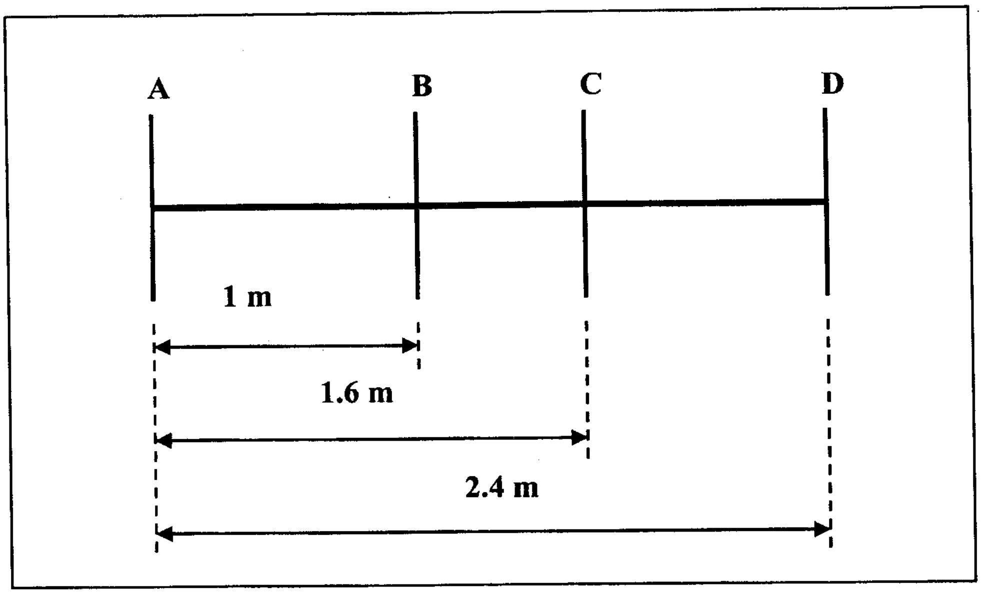
[b] **Apakah perbedaan di antara pengimbangan statik dan pengimbangan dinamik. Buktikan jika jisim berputar dalam keseimbangan dinamik ianya juga berada dalam keseimbangan statik tetapi tidak sebaliknya.**

Explain the difference between static and dynamic balancing. Prove that if a body is in dynamic balance, it will be in static balance but the reverse is not true.

(35 markah)

[c] **Empat jisim mempunyai magnitud 6 kg, 7 kg, 8 kg dan *m* kg masing-masing berputar pada satah A, B, C dan D. Jarak di antara satah ditunjukkan dalam Rajah S5[c]. Kesemua jisim mempunyai jejari putaran yang sama. Jika sistem jisim dalam keseimbangan sempurna, tentukan magnitud jisim *m* dan kedudukan sudutannya relatif kepada jisim yang lain.**

*Four masses of magnitudes 6 kg, 7 kg, 8 kg and **m** kg revolve in planes A, B, C and D, respectively. The planes are spaced as shown in Figure Q5[c]. The masses are all located at the same radius. Determine the magnitude of m and the relative angular positions of the masses for complete balance.*



Rajah S5[c]
Figure Q5[c]

(50 markah)

S6. [a] Profil pergerakan sesondol dan pengikut diberikan seperti berikut:

- **Pengikut naik semasa pusingan sesondol 60°**
- **Pengikut dalam keadaan rehat semasa pusingan sesondol 30° seterusnya**
- **Pengikut turun semasa pusingan sesondol 90° seterusnya, dan**
- **Pengikut dalam keadaan rehat semasa pusingan sesondol 180° seterusnya.**

Lejang pengikut adalah 30 mm. Lakarkan rajah anjakan (mengikut skala) apabila pengikut bergerak dengan:

i] gerakan harmonik mudah,
ii] gerakan pecutan dan rencatan malar.

A profile of motion of a cam and a follower is given as follows :

- *Outbreak during 60° of cam rotation*
- *Dwell for the next 30° of cam rotation*
- *Return stroke during next 90° of cam rotation, and*
- *Dwell of the remaining 180° of cam rotation.*

The stroke of the follower is 30 mm. Sketch the displacement diagram (appropriate scale) when the follower moves with:

i] simple harmonic motion,
ii] uniform acceleration and retardation.

(30 markah)

[b] **Jika sesondol beputar dengan kelajuan 300 p.s.m., tentukan nilai halaju dan nilai pecutan maksimum pengikut bagi gerakan dalam soalan S6[a], masing-masingnya semasa pengikut naik dan turun.**

If the cam rotates at 300 r.p.m., determine the maximum velocity and acceleration of the follower for the motions mention in question Q6[a] during outbreak and return stroke respectively.

(25 markah)

[c] **Bincangkan jenis-jenis tegasan yang teraruh dalam rim roda tenaga dan langkah-langkah mengatasinya.**

Discuss the various types of stresses induced in a flywheel rim and steps taken to overcome it.

(20 markah)

[d] **Bincangkan prosidur untuk menentukan saiz dan jisim roda tenaga dengan bantuan rajah momen.**

Explain the procedure for determining the size and mass of a flywheel with the help of a turning moment diagram.

(25 markah)

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Fundamental Equations of Dynamics

KINEMATICS

Particle Rectilinear Motion

Variable a	*Constant $a = a_c$*
$a = \frac{dv}{dt}$	$v = v_0 + a_c t$
$v = \frac{ds}{dt}$	$s = s_0 + v_0 t + \frac{1}{2}a_c t^2$
$a\,ds = v\,dv$	$v^2 = v_0^2 + 2a_c(s - s_0)$

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

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

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

Relative Motion

$\mathbf{v}_B = \mathbf{v}_A + \mathbf{v}_{B/A} \quad \mathbf{a}_B = \mathbf{a}_A + \mathbf{a}_{B/A}$

Rigid Body Motion About a Fixed Axis

Variable α	*Constant $\alpha = \alpha_c$*
$\alpha = \frac{d\omega}{dt}$	$\omega = \omega_0 + \alpha_c t$
$\omega = \frac{d\theta}{dt}$	$\theta = \theta_0 + \omega_0 t + \frac{1}{2}\alpha_c t^2$
$\omega\,d\omega = \alpha\,d\theta$	$\omega^2 = \omega_0^2 + 2\alpha_c(\theta - \theta_0)$

For Point P

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

Relative General Plane Motion—Translating Axes

$\mathbf{v}_B = \mathbf{v}_A + \mathbf{v}_{B/A(\text{pin})} \quad \mathbf{a}_B = \mathbf{a}_A + \mathbf{a}_{B/A(\text{pin})}$

Relative General Plane Motion—Trans. and Rot. Axis

$\mathbf{v}_B = \mathbf{v}_A + \boldsymbol{\Omega} \times \mathbf{r}_{B/A} \times (\mathbf{v}_{B/A})_{xyz}$

$\mathbf{a}_B = \mathbf{a}_A + \dot{\boldsymbol{\Omega}} \times \mathbf{r}_{B/A} + \boldsymbol{\Omega} \times (\boldsymbol{\Omega} \times \mathbf{r}_{B/A}) + 2\boldsymbol{\Omega} \times (\mathbf{v}_{B/A})_{xyz} \times (\mathbf{a}_{B/A})_{xyz}$

KINETICS

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

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

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

Equations of Motion

Particle	$\Sigma\mathbf{F} = m\mathbf{a}$
Rigid Body (Plane Motion)	$\Sigma F_x = m(a_G)_x$ $\Sigma F_y = m(a_G)_y$ $\Sigma M_G = I_G\alpha$ or $\Sigma M_P = \Sigma(\mathcal{M}_k)_P$

Principle of Work and Energy

$T_1 + U_{1-2} = T_2$

Kinetic Energy

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

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	$U_s = -(\frac{1}{2}ks_2^2 - \frac{1}{2}ks_1^2)$
Couple moment	$U_M = M\,\Delta\theta$

Power and Efficiency

$P = \frac{dU}{dt} = \mathbf{F}\cdot\mathbf{v} \quad \epsilon = \frac{P_{out}}{P_{in}} = \frac{U_{out}}{U_{in}}$

Conservation of Energy Theorem

$T_1 + V_1 = T_2 + V_2$

Potential Energy

$V = V_g + V_e$, where $V_g = \pm Wy$, $V_e = +\frac{1}{2}ks^2$

Principle of Linear Impulse and Momentum

Particle	$m\mathbf{v}_1 + \Sigma\int \mathbf{F}\,dt = m\mathbf{v}_2$
Rigid Body	$m(\mathbf{v}_G)_1 + \Sigma\int \mathbf{F}\,dt = m(\mathbf{v}_G)_2$

Conservation of Linear Momentum

$\Sigma(\text{syst. } m\mathbf{v})_1 = \Sigma(\text{syst. } m\mathbf{v})_2$

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

Principle of Angular Impulse and Momentum

Particle	$(\mathbf{H}_O)_1 + \Sigma\int \mathbf{M}_O\,dt = (\mathbf{H}_O)_2$ where $H_O = (d)(mv)$
Rigid Body (Plane motion)	$(\mathbf{H}_G)_1 + \Sigma\int \mathbf{M}_G\,dt = (\mathbf{H}_G)_2$ where $H_G = I_G\omega$ $(\mathbf{H}_O)_1 + \Sigma\int \mathbf{M}_O\,dt = (\mathbf{H}_O)_2$ where $H_O = I_O\omega$

Conservation of Angular Momentum

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