
UNIVERSITI SAINS MALAYSIA

Second Semester Examination
Academic Session 2008/2009
*Peperiksaan Semester Kedua
Sidang Akademik 2008/2009*

April/May 2009
April/Mei 2009

EMM 212/4 – Dynamics & Mechanisms
Dinamik & Mekanisma

Duration : 3 hours
Masa : 3 jam

INSTRUCTIONS TO CANDIDATE:
ARAHAN KEPADA CALON :

Please check that this paper contains **TEN (10)** printed pages, **TWO (2)** pages appendix and **SIX (6)** questions before you begin the examination.

*Sila pastikan bahawa kertas soalan ini mengandungi **SEPULUH (10)** mukasurat bercetak, **DUA (2)** mukasurat lampiran dan **ENAM (6)** soalan sebelum anda memulakan peperiksaan.*

Answer **FIVE (5)** questions.
*Jawab **LIMA (5)** soalan.*

Appendix/Lampiran :

1. Suitable Diametral Pitches for 20⁰ Mild Steel Gear With Standard Face Width
[1 page/mukasurat]
2. Number of Teeth for Commercially Available Stock Gears
[1 page/mukasurat]

Answer all questions in **English** OR **Bahasa Malaysia** OR a combination of both.
*Calon boleh menjawab semua soalan dalam **Bahasa Malaysia** ATAU **Bahasa Inggeris** ATAU kombinasi kedua-duanya.*

Each question must begin from a new page.
Setiap soalan mestilah dimulakan pada mukasurat yang baru.

- Q1. [a] A uniform 50 kg crate rests on a horizontal surface for which the coefficient of kinetic friction is $\mu_k = 0.2$. Determine the crate's acceleration if a force of $P = 700$ N is applied to the crate as shown in Figure Q1[a].

Bongkah berjisim seragam 50 kg berada dalam keadaan rehat di atas permukaan mendatar yang mempunyai pekali geseran kinetik $\mu_k = 0.2$. Tentukan pecutan bongkah jika daya $P = 700$ N dikenakan pada bongkah seperti yang ditunjukkan dalam Rajah Q1[a].

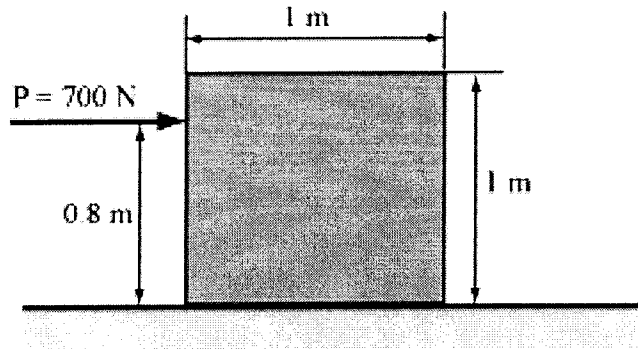


Figure Q1[a]
Rajah S1[a]

(50 marks/markah)

- [b] The 6 N particle in Figure is subjected to the action of its weight and forces $F_1 = \{2i+6j-2tk\}$ N, $F_2 = \{t^2i-4tj-k\}$ N and $F_3 = \{-2ti\}$ N, where t is in seconds. Determine the distance the particle is from the origin 2 s after being released from rest.

Satu zarah 6 N dikenakan berat sendiri dan daya-daya $F_1 = \{2i+6j-2tk\}$ N, $F_2 = \{t^2i-4tj-k\}$ N dan $F_3 = \{-2ti\}$ N, di mana t dalam saat. Tentukan jarak zarah dari asalan selepas 2 s dilepaskan dari keadaan rehat.

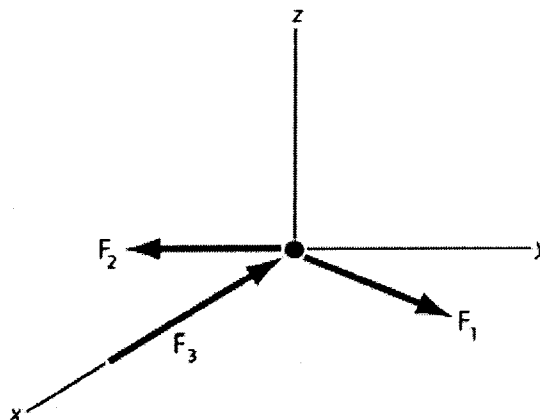


Figure Q1[b]
Rajah S1[b]

(50 marks/markah)

- Q2. [a]** An automobile tire has a mass of 7 kg and radius of gyration $k_G = 0.3$ m. If it is released from rest at A on the incline, determine its angular velocity when it reaches the horizontal plane at B. The radius of tire is 0.4 m and the tire rolls without slipping.

Sebagai tayar kereta berjirim 7 kg dengan jejari legaran $k_G = 0.3$ m. Jika ia dilepaskan daripada keadaan rehat pada A di atas permukaan condong, tentukan halaju sudut apabila ia sampai di satah mengufuk. Tayar berjirim 0.4 m dan tayar bergolek tanpa gelinciran.

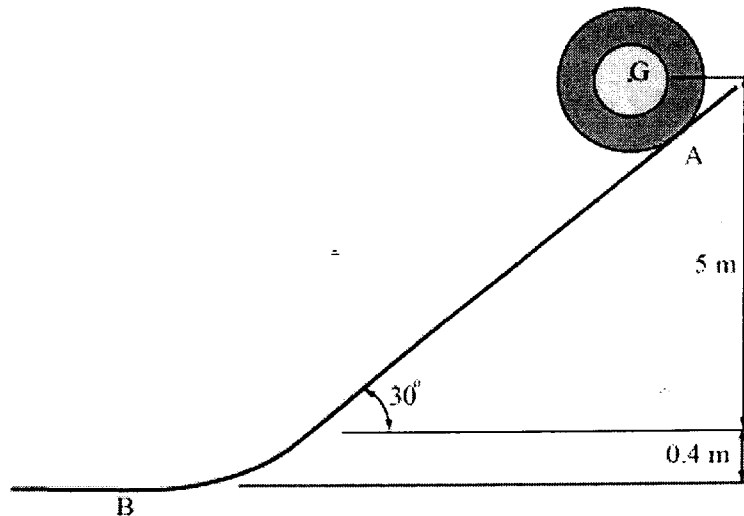


Figure Q2[a]
Rajah S2[a]

(30 marks/markah)

- [b]** The 20 kg disk is originally at rest, and the spring holds it in equilibrium. A couple moment of $M = 30$ Nm is then applied to the disk as shown in Figure Q2[b]. Determine how far the center of mass of the disk travels down along the incline, measured from the equilibrium position, before it stops. The disk rolls without slipping.

Pada asalnya, cakera yang berjirim 20 kg berada pada keadaan rehat, dan pegas bertindak dalam keseimbangan. Momen gandingan $M = 30$ Nm dikenakan seperti yang ditunjukkan dalam Rajah Q2[b]. Tentukan berapa jauh pusat jisim cakera itu bergerak di atas permukaan condong, diukur dari kedudukan keseimbangan sebelum ia berhenti. Cakera bergolek tanpa gelinciran.

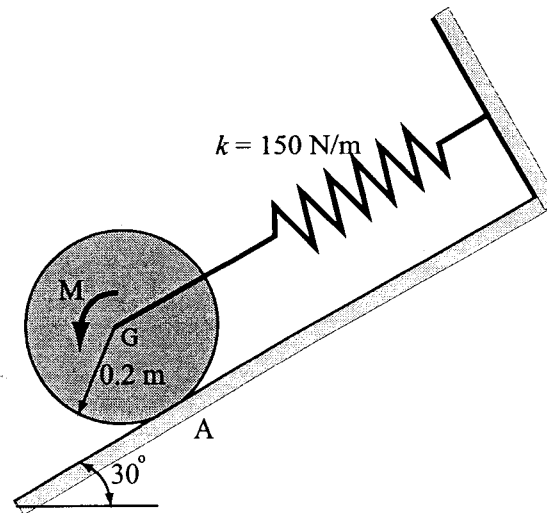


Figure Q2[b]
Rajah S2[b]

(70 marks/markah)

- Q3. [a] The 10 kg wheel in Figure has a radius of gyration $k_A = 200\text{ mm}$. If the wheel is subjected to a moment $M = (5t)\text{ Nm}$, where t is in seconds, determine its angular velocity when $t = 3\text{ s}$ starting from rest. Also compute the reactions which the fixed pin A exerts on the wheel during the motion. Solve the problem using the principal of impulse and momentum.

Roda berjisim 10 kg mempunyai jejari legaran $k_A = 200\text{ mm}$. Jika dikenakan moment $M = (5t)\text{ Nm}$, dimana t dalam saat, tentukan halaju sudut apabila $t = 3\text{ s}$ bermula dari keadaan rehat. Seterusnya tentukan tindakbalas pada pin A yang dikenakan keatas roda semasa gerakan tersebut. Selesai masalah ini menggunakan prinsip impuls dan momentum.

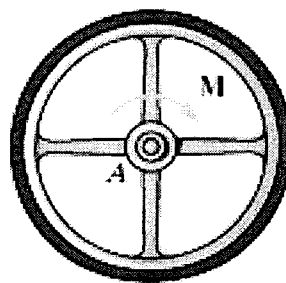


Figure Q3[a]
Rajah S3[a]

(50 marks/markah)

- [b] The disk with radius $r = 150$ mm in Figure has mass of 20 kg and is originally spinning at the end of the strut with angular velocity $\omega = 60$ rad/s. If it is then placed against the wall, for which the coefficient of kinetic friction is $\mu_k = 0.3$, determine the time required for the motion to stop and the force in strut BC during this time? Solve the problem using the principal of impulse and momentum.

Sebuah cakera berjari $r = 150$ mm dengan jisim 20 kg pada asalnya berputar di hujung topang dengan halaju sudut $\omega = 60$ rad/s. Jika ia diletakkan pada dinding dengan pekali geseran kinetik = 0.3, tentukan masa yang diperlukan untuk gerakan tersebut berhenti dan daya pada topang BC pada masa itu? Selesai masalah ini menggunakan prinsip impuls dan momentum.

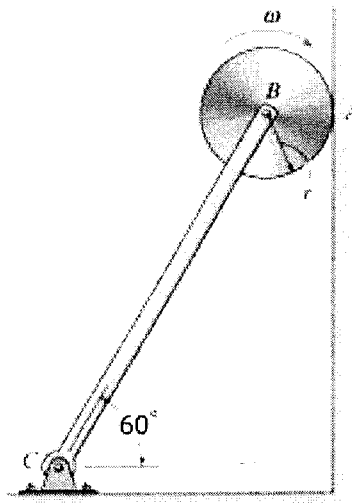


Figure Q3[b]
Rajah S3[b]

(50 marks/markah)

Q4. [a] A sketch of a truck used to deliver supplies to passenger jets is shown in Figure Q4[a].

- (i) Draw a kinematic diagram of the mechanism.
- (ii) Calculate the mobility for the mechanism shown.

Satu lakaran sebuah trak digunakan untuk menghantar barang-barang permintaan jet ditunjukkan dalam Rajah S4[a].

- (i) *Lukis diagram kinematik untuk mekanisma yang digunakan.*
- (ii) *Kirakan kebebasan mekanisma tersebut*

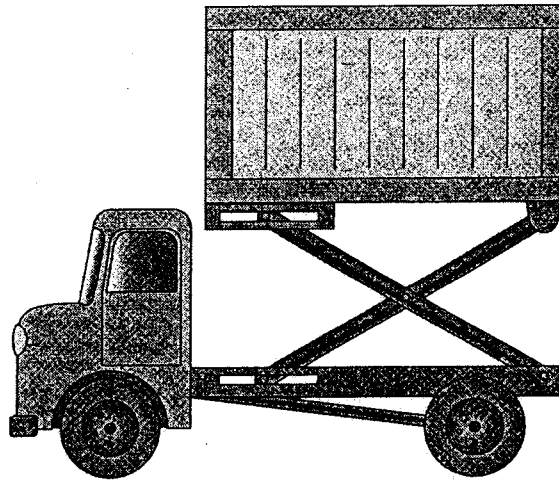


Figure Q4[a]
Rajah S4[a]

(20 marks/markah)

[b] The mechanism shown in Figure Q4[b] is used to feed cartons to a labeling machine and, at the same time, to prevent the stored cartons from moving down. At full speed, the driveshaft rotates clockwise with an angular velocity of 250 rpm. At the instant shown,

- (i) Draw the kinematic diagram of the mechanism
- (ii) Find the velocity of the ram
- (iii) Determine the acceleration of the ram
- (iv) Determine the angular acceleration of the connecting rod.

Mekanisma yang ditunjukkan dalam Rajah S4[b] digunakan untuk menyalurkan kotak ke dalam mesin label dan pada masa yang sama, untuk menghalang kotak yang telah disimpan daripada bergerak jatuh. Pada halaju penuh, pemancu aci berputar arah jam dengan halaju sudut 250 rpm. Pada ketika yang ditunjukkan,

- (i) Lukis diagram kinematic mekanisma tersebut
- (ii) Cari halaju ram
- (iii) Tentukan pecutan ram tersebut
- (iv) Tentukan pecutan sudut batang sambungan.

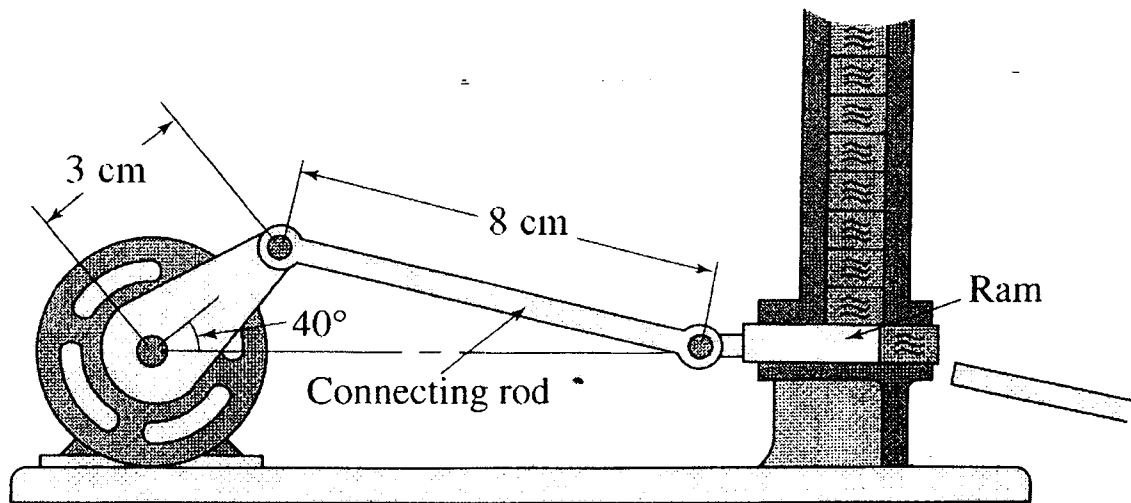


Figure Q4[b]
Rajah S4[b]

(80 marks/markah)

Q5. Figure Q5 shows a four-bar mechanism. Link 2 rotates counterclockwise at a constant 10 rad/s. The weight of links 2 and 3 is negligible, and link 4 is 17 kg. The radius of gyration of link 4 relative to the center of gravity is 45 mm. For $\beta = 45^\circ$,

- (i) Determine the linear acceleration of the center of gravity of link 4,
- (ii) Determine the angular acceleration of link 4,
- (iii) Determine the inertial force and inertial torque of link 4,
- (iv) Generate the equilibrium equations for links 2, 3 and 4.
- (v) Express the final equations in vector format. Do not solve them.

Note: Radius of gyration is $I = mk^2$ where I is moment of inertia, m is mass and k is radius of gyration.

Rajah S5 menunjukkan mekanisma empat bar. Penyambung 2 berputar lawan arah jam pada halaju tetap 10 rad/s. Berat penyambung 2 dan 3 boleh diabaikan, dan berat penyambung 4 ialah 17 kg. Jejari girasi penyambung 4 relatif pusat graviti ialah 45 mm. Untuk $\beta = 45^\circ$,

- (i) *Tentukan pecutan linear pusat graviti penyambung 4*
- (ii) *Tentukan pecutan sudut penyambung 4*
- (iii) *Tentukan daya inersia dan kilasan inersia penyambung 4*
- (iv) *Terbitkan persamaan keseimbangan untuk penyambung-penyambung 2, 3 dan 4.*
- (v) *Letakkan persamaan-persamaan akhir dalam bentuk vektor. Jangan selesaikan persamaan-persamaan ini.*

Nota: 'Radius of gyration' ialah $I = mk^2$ di mana I ialah momen inersia, m ialah jisim dan k ialah 'radius of gyration'

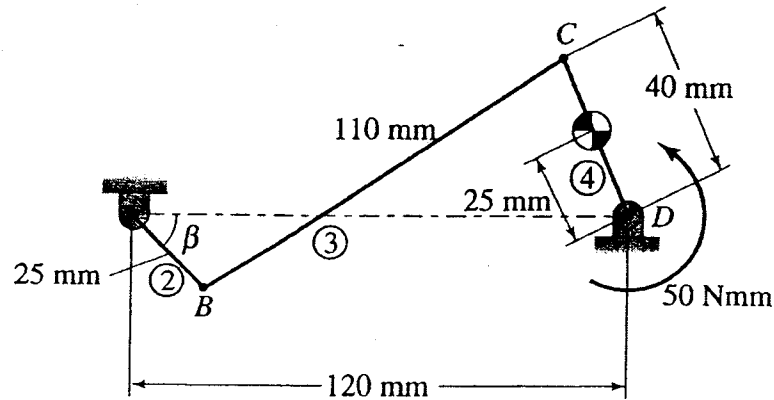


Figure Q5
Rajah S5

(100 marks/markah)

- Q6. [a] A pair of 20° , mild-steel gears are to be selected for an application where they need to transfer 3 hp. The gears must fit into a housing where the center distance is 14 cm. The pinion will be driven at 1750 rpm and gear must rotate as close to 290 rpm as possible. Determine an appropriate set of catalog gears, from the Appendix, for this application.

Sepasang 20° gear berkeluli lembut akan dipilih untuk satu aplikasi di mana mereka perlu menghantar 3 hp. Gear ini mesti masuk ke dalam tempat khas di mana jarak pusat ialah 14 cm. Pacuan akan dipandu pada 1750 rpm dan gear mesti berputar sehampir dengan 290 rpm. Tentukan set gear yang sesuai daripada katalog seperti terletak dalam Lampiran untuk aplikasi ini.

(30 marks/markah)

- [b] A gear train is shown in Figure Q6[b]. The gears have the following properties : $N_2 = 18$ teeth; $N_3 = 72$ teeth and $P_d = 10$; $N_4 = 16$ teeth and $P_d = 8$; and $N_5 = 48$ teeth. Determine :

- (i) the velocity of gear 5 as gear 2 drives at 1200 rpm clockwise.
- (ii) the center distance between gears 2 and 5.

Satu pacuan gear ditunjukkan dalam Rajah S6[b]. Gear-gear tersebut berparameter seperti berikut: $N_2 = 18$ gigi; $N_3 = 72$ gigi dan $P_d = 10$; $N_4 = 16$ gigi dan $P_d = 8$; dan $N_5 = 48$ gigi. Tentukan:

- (i) halaju gear 5 jika gear 2 dipacu pada 1200 rpm ikut arah jam
- (ii) jarak pusat di antara gear 2 dan 5.

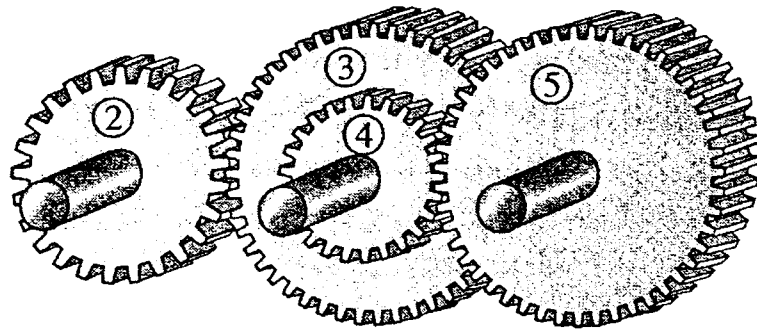


Figure Q6[b]
Rajah S6[b]

(30 marks/markah)

[c] Knowing that sun gear (S) rotates at 120 rpm clockwise and ring gear (I) or annulus rotates at 80 rpm counter clockwise as shown in Figure Q6[c], determine :

- (i) the angular velocity of the arm A.
- (ii) the angular velocity of the planet gear (P).

The number in the bracket refers to the number of teeth respectively.

Dengan mengetahui gear matahari (S) berputar pada 120 rpm ikut arah jam dan gear cincin (I) berputar pada 80 rpm ikut lawan jam seperti yang ditunjukkan dalam Rajah S6[c], tentukan :

- (i) *halaju putaran anggota A.*
- (ii) *halaju putaran gear planet (P)*

Nombor dalam kurungan menunjukkan nombor gigi gear-gear berkenaan.

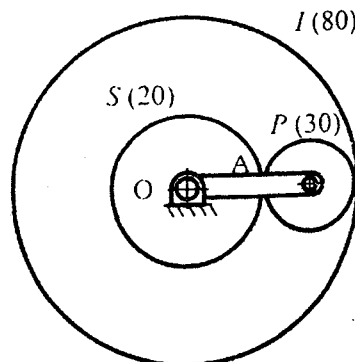


Figure Q6[c]
Rajah S6[c]

(40 marks/markah)

APPENDIX 1
LAMPIRAN 1

Suitable Diametral Pitches for 20° Mild Steel Gear
With Standard Face Width

Power hp	Pinion rpm								
	50	100	300	600	900	1200	1800	2400	3600
0.05	20	20	24	32	32	32	32	32	32
0.10	16	20	20	24	24	24	32	32	32
0.25	12	16	20	20	24	24	24	24	24
0.33	10	12	16	20	20	24	24	24	24
0.50	10	12	16	20	20	20	20	24	24
0.75	8	10	12	16	16	20	20	20	20
1.0	6	10	12	16	16	16	20	20	20
1.5	6	8	12	12	16	16	16	16	20
2.0	6	6	10	12	12	12	16	16	16
3.0	5	6	8	10	12	12	12	12	16
5.0	4	5	6	8	10	10	12	12	12
7.5	4	5	6	8	8	8	10	10	10
10	3	4	6	6	6	8	8	8	10
15	2	4	5	6	6	6	6	6	8
20	2	3	4	5	6	6	6	6	—
25	—	3	4	5	5	5	6	5	—
30	—	2	4	4	5	5	5	—	—
40	—	2	3	4	4	—	—	—	—
50	—	—	3	4	4	—	—	—	—

APPENDIX 2
LAMPIRAN 2

Number of Teeth for Commercially Available Stock Gears

32 Diametral Pitch								
12	16	20	28	36	48	64	80	112
14	18	24	32	40	56	72	96	128
24 Diametral Pitch								
12	18	24	30	42	54	72	96	144
15	21	27	36	48	60	84	120	
20 Diametral Pitch								
12	16	24	35	50	80	100	160	
14	18	25	40	60	84	120	180	
15	20	30	45	70	90	140	200	
16 Diametral Pitch								
12	16	24	32	48	64	96	160	
14	18	28	36	56	72	128	192	
15	20	30	40	60	80	144		
12 Diametral Pitch								
12	15	20	28	42	60	84	120	168
13	16	21	30	48	66	96	132	192
14	18	24	36	54	72	108	144	216
10 Diametral Pitch								
12	16	24	30	45	55	80	120	200
14	18	25	35	48	60	90	140	
15	20	28	40	50	70	100	160	
8 Diametral Pitch								
12	16	22	32	44	60	80	112	
14	18	24	36	48	64	88	120	
15	20	28	40	56	72	96	128	
6 Diametral Pitch								
12	16	24	33	48	66	96		
14	18	27	36	54	72	108		
15	21	30	42	60	84	120		
5 Diametral Pitch								
12	16	24	30	45	70	110	160	
14	18	25	35	50	80	120	180	
15	20	28	40	60	100	140		