Second Semester Examination
2018/2019 Academic Session

June 2019

EEM323 – Instrumentation & Measurement Systems
(Sistem Peralatan & Pengukuran)

Duration : 3 hours
(Masa : 3 jam)

Please check that this examination paper consists of FIFTEEN (15) pages of printed material before you begin the examination.

[Sila pastikan bahawa kertas peperiksaan ini mengandungi LIMA BELAS (15) muka surat bercetak sebelum anda memulakan peperiksaan ini.]

Instructions: This question paper consists of **SIX (6)** questions. Answer **FIVE (5)** questions. All questions carry the same marks.

*[**Arahan:** Kertas soalan ini mengandungi **ENAM (6)** soalan. Jawab **LIMA (5)** soalan. Semua soalan membawa jumlah markah yang sama].*

Answer to any question must start on a new page.

[Mulakan jawapan anda untuk setiap soalan pada muka surat yang baharu].

"In the event of any discrepancies, the English version shall be used".

[Sekiranya terdapat sebarang percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah diguna pakai].

1. (a) Some important specifications of a typical load cell are given in Table 1(a).

Beberapa spesifikasi penting bagi sel beban tipikal diberikan di dalam Jadual 1(a).

Table 1(a)
Jadual 1(a)

Parameters/*Parameter*	Specifications/*Spesifikasi*
Non-linearity/*Tak-lineariti*	$\pm$ 0.5 %
Hysterisis/*Histeresis*	$\pm$ 0.5 %
Repeatibility/*Kebolehulangan*	$\pm$ 0.25 %
Bridge resistance/*Rintangan tetimbang*	350 Ω nominal

Using neatly drawn diagram, explain clearly all parametes in Table 1(a).

Menggunakan lakaran gambarajah yang kemas, terangkan dengan jelas semua parameter di dalam Jadual 1(a).

(40 marks/*markah*)

(b) A pillar load cell comprising of two identical strain gauges R_1 and R_4 as shown in Figure 1(b)(i) is used for force measurement. The strain gauges are arranged in such a way that the applied force *F* causes a longtudinal compressive strain e_L on R_4, and transverse tensile strain e_T on R_1. In this case the change of resistance of strain gauge ΔR, e_L and e_T are defined as follows:

Sel pilar beban mengandungi dua tolok terikan sepunya R_1 dan R_4 seperti yang ditunjukkan di dalam Rajah 1(b)(i) digunakan untuk pengukuran daya. Kedua-dua tolok terikan diatur sedemikian rupa supaya daya F mengakibatkan R_4 mengalami terikan mampatan membujur e_L dan R_1 mengalami terikan tegangan melintang e_T . Dalam kes ini perubahan rintangan tolok terikan ΔR, e_L dan e_T ditakrifkan seperti berikut:

$$\Delta R = GR_0e, \quad e_L = -\frac{F}{AE}, \quad e_T = -\upsilon e_L$$

where e is the strain, G is the gauge factor, R_0 is the unstrained resistance, *A* is a cross sectional area of the pillar, *E* and υ are respectively Young's modulus and Poisson's ratio for the pillar material. The strain gauges are mounted into the wheastone bridge as shown in Figure 1(b)(ii).

dan e terikan, G faktor tolok, R_0 rintangan tanpa terikan, A luas keratan rentas pilar, E dan υ masing-masingnya modulus Young dan nisbah Poisson bahan pilar. Kedua-dua tolok ini juga dimasukkan ke dalam tetimbang wheastone seperti yang ditunjukkan di dalam Rajah 1(b)(ii).

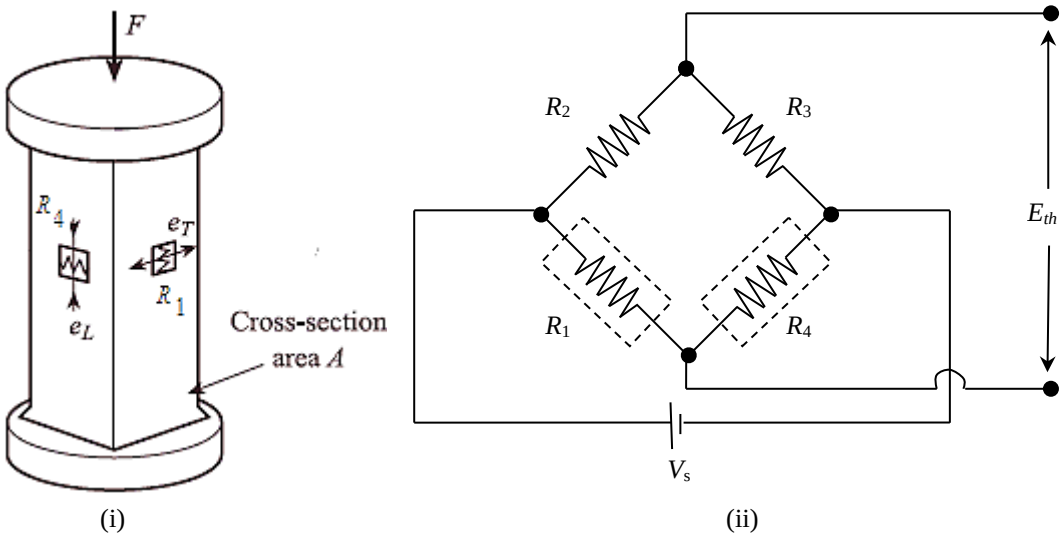


Figure 1(b)
Rajah 1(b)

(i) derive the Thevenin voltage, E_{th},
terbit voltan Thevenin, E_{th},

(20 marks/*markah*)

(ii) assuming $R_0 = 100\ \Omega$, $G = 2.5$, $V_s = 10$ V, $\upsilon = 0.3$, $A = 0.25$ m^2 and $E = 17$ GPa, plot E_{th} versus F for:
$F = (0, 0.4, 0.8, 1.2, 1.6, 2.0, 2.4, 2.8, 3.2, 3.6, 4.0)$ GN ,

mengandaikan $R_0 = 100\ \Omega$, $G = 2.5$, $V_s = 10$ V, $\upsilon = 0.3$, $A = 0.25$ m^2 dan $E = 17$ GPa, plot E_{th} melawan F untuk:
$F = (0, 0.4, 0.8, 1.2, 1.6, 2.0, 2.4, 2.8, 3.2, 3.6, 4.0)$ GN ,

(15 marks/*markah*)

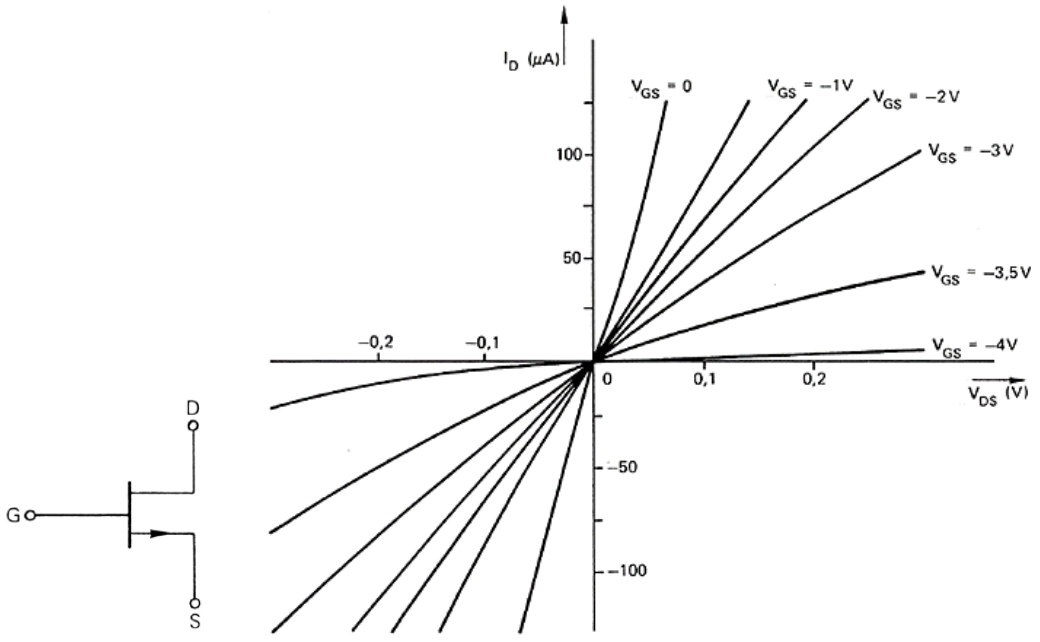
…4/-

(iii) from 1(b)(ii), calculate the maximum non-linearity, $N(I)$, and,
daripada 1(b)(ii), kira tidak-lineariti maksimum, $N(I)$, dan,
(15 marks/*markah*)

(iv) suggest one way to reduce $N(I)$.
cadang satu cara untuk mengurangkan $N(I)$.
(10 marks/*markah*)

2. (a) The circuit symbol for Junction Field Effect Transistor (JFET) is shown in Figure 2(a)(i). Meanwhile Figure 2(a)(ii) shows the voltage-current characteristics of the channel for low currents and various values of the gate-source voltage.

Simbol litar Transistor Simpang Kesan Medan (JFET) ditunjukkan di dalam Rajah 2(a)(i). Manakala Rajah 2(a)(ii) menunjukkan sifat arus-voltan bagi saluran untuk arus rendah dan beberapa nilai voltan get-sumber.



(i) (ii)

Figure 2(a)
Rajah 2(a)

Using Figure 2(a) explain clearly how JFET can be used as an electronic switch. State ONE principal advantage of JFET compared to bipolar transistor when used as a switch.

Menggunakan Rajah 2(a), terangkan dengan jelas bagaimana JFET boleh digunakan sebagai suis elektronik. Nyatakan SATU kelebihan utama JFET berbanding dengan transistor bipolar apabila digunakan sebagai suis.

(40 marks/*markah*)

(b) The voltage switching circuit of a series-type switch is shown in Figure 2(b).

Litar pensuisan voltan bagi suis jenis bersiri ditunjukkan di dalam Rajah 2(b).

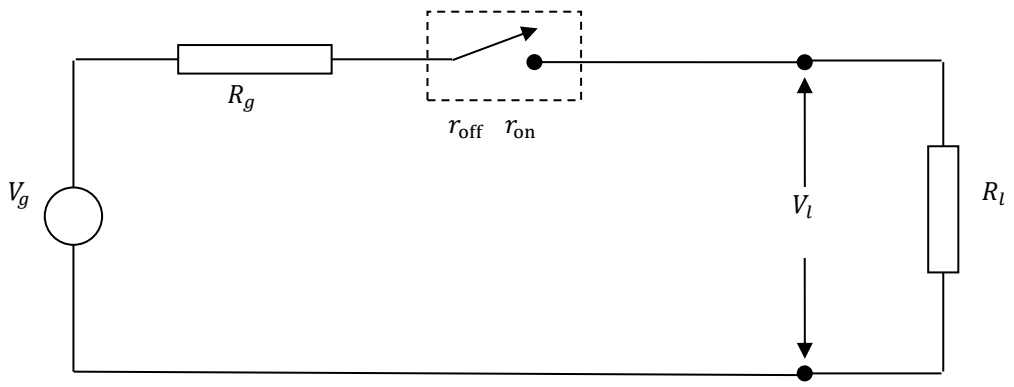


Figure 2(b)
Rajah 2(b)

If $r_{on} = 1\Omega$ and $r_{off} = 1\ \text{k}\Omega$

(i) derive the condition for R_g and R_l if the maximum transfer error in the ON-STATE is 10 %,

terbitkan syarat bagi R_g dan R_l jikalau ralat pemindahan maksimum KEADAAN-TUTUP ialah 10 %,

(20 marks/*markah*)

(ii) derive the condition for R_g and R_l if the maximum transfer error in the OFF-STATE is 1 %,

terbitkan syarat bagi R_g dan R_l jikalau ralat pemindahan maksimum KEADAAN-BUKA ialah 1 %,

(20 marks/*markah*)

(iii) from 2(b)(i) and 2(b)(ii) calculate R_g and R_l.

daripada 2(b)(i) dan 2(b)(ii) kira R_g dan R_l .

(20 marks/*markah*)

3. (a) Using suitable diagram, explain clearly the differences between asynchronous and synchronous data transmission systems. Give one example for each system.

Menggunakan contoh yang sesuai, terangkan dengan jelas perbezaan di antara sistem penghantaraan data tak segerak dan segerak. Berikan satu contoh untuk setiap sistem.

(40 marks/*markah*)

(b) One error correcting data transmision system has been proposed to correct a single incorrect digit in a complete code word of *m* digits. The idea is to send the information digits in *n* groups, each containing *m* digits. The information digits are arranged $n \times m$ matrix form and parity bits added to each row and column at the transmitter. In this case an even parity bit is assumed with the following rules:

Sebuah sistem pembetul ralat penghantaran data telah dicadangkan untuk membetulkan satu digit yang tersilap di dalam kod perkataan lengkap mengandungi m digit. Idenya ialah menghantar digit-digit maklumat di dalam n kumpulan, setiapnya mengandungi m digit. Digit-digit maklumat disusun dalam bentuk matrik $n \times m$ dan bit-bit pariti dimasukkan di setiap baris dan jalur di penghantar. Di dalam kes ini, bit pariti genap diandaikan dengan peraturan-peraturan berikut:

$$0 \oplus 0 = 0, \quad 0 \oplus 1 = 1, \quad 1 \oplus 0 = 1, \quad 1 \oplus 1 = 0$$

An example of information at the transmitter in 4×4 arrangement is shown in Table 3(b)(i), while Table 3(b)(ii), and Table 3(b)(ii) are information at the receiver. In all cases *r* indicates the parity bit.

Contoh maklumat di penghantar bagi susunan 4×4 *ditunjukkan di dalam Jadual 3(b)(i) manakala Jadual 3(b)(ii) dan Jadual 3(b)(iii) adalah maklumat di penerima. Untuk semua kes r mewakili bit pariti.*

Table 3(b)

Jadual 3(b)

Col / Row	1	2	3	4	*r*
1	0	0	0	1	
2	0	0	1	1	
3	0	1	1	0	
4	1	0	0	1	
r					

(i)

Col / Row	1	2	3	4	*r*
1					0
2					0
3					0
4					1
r	0	1	1	1	

(ii)

Col / Row	1	2	3	4	*r*
1					0
2					0
3					0
4					1
r	0	1	1	1	

(iii)

(i) compute the parity bits for each row and column in Table 3(b)(i),

kira bit-bit pariti untuk setiap baris dan jalur di dalam Jadual 3(b)(i),

(20 marks/*markah*)

(ii) if the parity bits at the receiver are given in Table 3(b)(ii), determine the received bits,

jikalau bit-bit pariti di penerima diberikan di dalam Jadual 3(b)(ii), tentutkan bit-bit yang diterima.

(20 marks/*markah*)

(iii) repeat 3(b)(ii) for Table 3(b)(iii).

ulangi 3(b)(ii) bagi Jadual 3(b)(iii)

(20 marks/*markah*)

4. (a) Give 2 considerations of parameter in selecting the flow meter, and what kind of information we get from having the Reynold number.

Berikan 2 parameter yang perlu dipertimbangkan di dalam pemilihan meter alir, dan jenis maklumat yang kita dapat daripada mempunyai nombor Reynold.

(15 marks/*markah*)

(b) The flow rate of methanol at 20 Celcius (ρ=788.4 kg/m^{3}and μ=5.857 ×10^{-4} kg/m.s) through a 4-cm diameter pipe is to be measured with a 3-cm-diameter orifice meter equipped with a mercury manometer across the orifice place, as shown in Figure 4(b). If the differential height of the manometer is read to be 11 cm. Assume C_d is 0.61. Determine:

Kadar aliran metanol pada 20 Celcius (ρ=788.4 kg/m^3 dan μ=5.857 ×10^{-4} kg/m.s) melalui paip yang bergaris pusat 4 cm perlu diukur menggunakan meter orific bergaris pusat 3 cm dan disambungkan dengan manometer merkuri seperti yang ditunjukkan dalam Rajah 4(b). Jika perbezaan ketinggian manometer yang dibaca adalah 11 cm. Anggap C_d adalah 0.61. Tentukan:

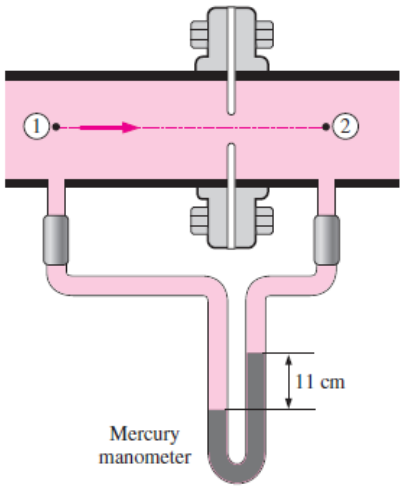


Figure 4(b)

Rajah 4(b)

(i) Volume flow rate of methanol
Kadar aliran isipadu methanol

(30 marks/*markah*)

(ii) Mass flow rate of methanol in hour
Kadar aliran jisim metanol dalam jam

(10 marks/*markah*)

(iii) Average flow velocity
purata kelajuan aliran

(10 marks/*markah*)

(c) Refer to Figure 4(c).
Rujuk Rajah 4(c).

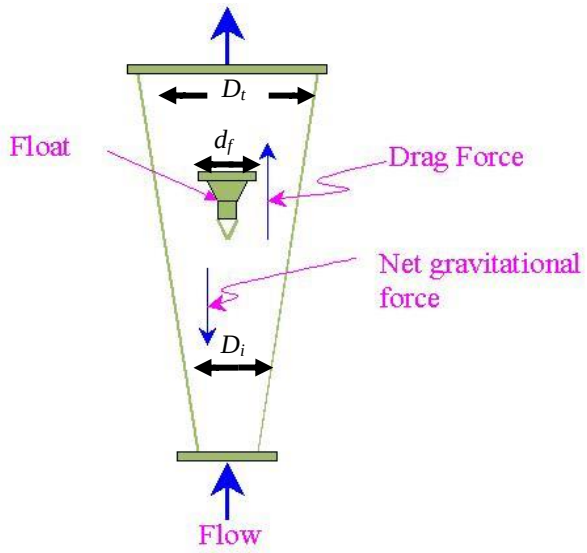


Figure 4(c)
Rajah 4(c)

(i) State the name and type of flow meter in Figure 4(c).
Nyatakan nama dan jenis alir meter di Rajah 4(c).

(10 marks/*markah*)

(ii) Refer to the flow meter in Figure 4(c). The flow enters the bottom of a vertically placed tapered tube and causes the float to move upwards. The float will rise to a point in the tube where the drag force and buoyant force is balanced by the weight of float. Thus, based on the force balance equation of the float,

Aliran meter dalam Rajah 4(c). Aliran masuk ke dalam bahagian bawah tiub yang dipasang secara menegak dan menyebabkan apungan bergerak ke atas. Apungan akan meningkat kepada satu titik dalam tiub di mana daya seret dan daya apung adalah diimbangi dengan berat apungan. Oleh itu, berdasarkan persamaan baki apungan,

$F_{drag} + F_{buoyancy} = F_{weight}$

Derive the flow rate equation and assume C_d, A_t, A_f, ρ_{ff}, ρ_f, g, V_f, p_d, p_u and K are coefficients of the discharge, tube area, float area, flowing fluid density, float density, gravity, float volume, pressures at the downward surfaces of the float, pressures at the upward surfaces of the float and constant of the flow meter in Figure 4(c), respectively. (Assume the $(At-Af)/Af << 1$)

Terbitkan persamaan kadar aliran dan anggapkan C_d, A_t, A_f, ρ_{ff}, ρ_f, g, p_d, p_u dan K ialah masing-masing pekali kadar alir, luas tiub, luas apungan, ketumpatan cecair mengalir, ketumpatan apung, graviti, isipadu terapungan, tekanan di bawah permukaan yang terapung, tekanan di permukaan menaik terapung dan tetap meter alir seperti di dalam Rajah 4(c). (Anggapakan $(At-Af)/Af << 1$)

(25 marks/*markah*)

5. (a) Refer to Figure 5(a)
Rujuk Rajah 5(a)

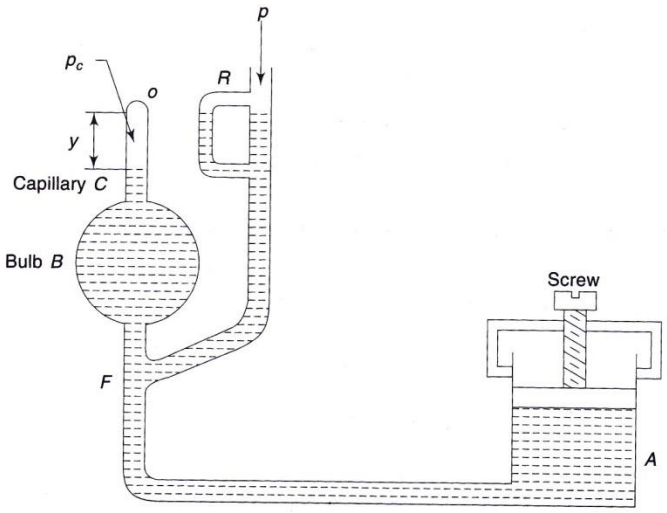


Figure 5(a)
Rajah 5(a)

(i) Explain the working mechanism for this pressure meter.

Terangkan mekanisma operasi untuk meter tekanan ini.

(15 marks/*markah*)

(ii) Assume A, V_c, P_c and V_F are area of cross-section of capillary, volume of gas in capillary, pressure of gas in the **capillary C** after compression and volume of capillary and bulb till F. Derive the pressure

*Anggapkan A, V_c, P_c dan V_F adalah luas keratan rentas tiub, isipadu gas dalam tiub, tekanan gas dalam **tiub C** selepas pemampatan dan isipadu tiub dan mentol sehingga F. Terbitkan tekanan*

$$P = \frac{Ay^2}{V_F - A\,y}$$

(20 marks/*markah*)

(iii) For a capillary with diameter 1 mm and, area between capillary and tube down to its opening equal to 90 cm^3. Calculate the pressure indicated by a reading of 3 cm on the capillary tube.

Bagi suatu garis pusat tiub rerambut dengan diameter 1 mm dan kawasan diantara tiub rerambut dan tiub bawah ke pembukaannya adalah 90 cm^3. Hitungkan tekanan yang ditunjukkan oleh bacaan 3 cm pada tiub rerambut.

(20 marks/*markah*)

(b) Give 2 types of elastic transducer and example for each type.

Berikan 2 jenis transduser anjal dan contoh untuk setiap satu.

(15 marks/*markah*)

(c) A variable capacitance pressure gauge has the following specifications:

Pemboleh ubah tolok tekanan pemuat mempunyai spesifikasi seperti berikut:

diameter of clamped diaphragm = 20 mm,
diameter of fixed electrode = 15 mm,
thickness of diaphragm = 1mm,
Young's Modulus E of diaphragm material = $2.07 \times 10^5 N/mm^2$,
Poisson's ratio v = 0.3, and initial air gap = 1mm.

The variable capacitance due to change of air gap, forms a part circuit of Figure 5(c). Based on the capacitance equation given by:

diameter gegendang diapit = 20 mm,
diameter elektrod tetap = 15 mm,
ketebalan gegendang = 1mm,
Young Modulus E bahan gegendang = $2.07 \times 10^5 N/mm^2$,
nisbah Poisson v = 0.3 , dan ruang udara asal = 1mm.

Perubahan pemuat disebabkan oleh perubahan ruang udara dan membentuk sebahagian litar daripada Rajah 5(c). Berdasarkan persamaan kapasitif yang diberikan oleh:

$$C = \frac{b^2}{3.6\,d} + \frac{0.0174\,(1-\nu^2)\,p}{Ed^2\,t^3}\,[b^6 + 3R^2b^2\,(R^2 - b^2)]$$

Determine the sensitivity (V/pa) of the instrument, given V = 12V and R = $10^5\Omega$.

Tentukan sensitiviti (V / pa) instrumentasi tersebut, diberikan V = 12V dan R = $10^5\ \Omega$.

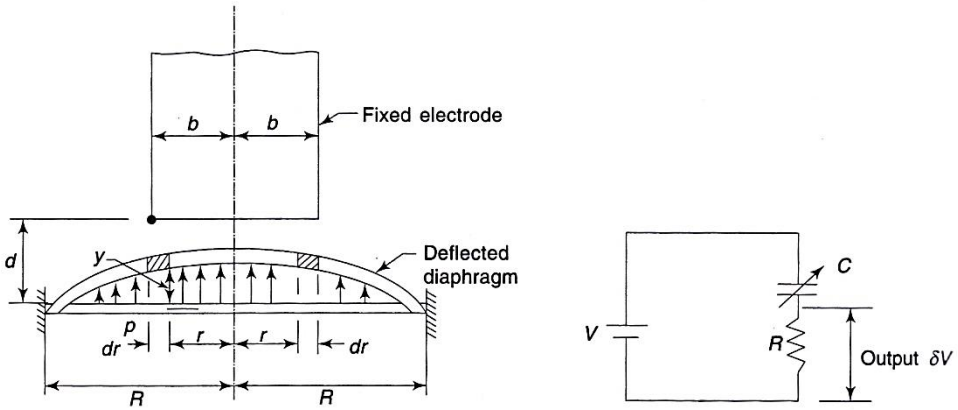


Figure 5(c)

Rajah 5(c)

(30 marks/*markah*)

6. (a) In a seismic instrument, mass m = 100 g, spring stiffness = 1 N/mm. Damping ratio= 0.4.

Dalam instrumentasi seismik, jisim m = 100 g, ketegangan spring = 1 N/mm. Nisbah redaman = 0.4.

(i) Find the amplitude of recorded motion if the motion of be measured is 3 sin 200 t (mm)

Cari amplitud dirakam jika gerakan diukur ialah 3 sin 200 t (mm)

…14/-

(ii) Find the maximum frequency for which instrument can be used as an accelero-meter if the error is not to exceed 10%.

Dapatkan frekuensi maksimum bagi instrumentasi yang boleh digunakan sebagai meter pecutan jika kesilapan itu tidak boleh melebihi 10%.

(30 marks/*markah*)

(b) Refer to Figure 6(b). An engine is expected to develop 5 kW of mechanical output while running at an angular speed of 1200 rpm. A brake drum of 250 mm diameter is available. It is proposed to design a Prony brake dynamometer using a spring balance as the force measuring instrument. The spring balance can measure a maximum force of 100 N.

Rujuk rajah 6(b), 5 kW keluaran mekanikal dijangkakan dapat dibangunkan oleh enjin apabila dioperasikan dengan kelajuan sudut 1200 rpm. Garis pusat brek gelendong adalah 250 mm. Dicadangkan untuk mereka bentuk brek dinamometer Prony menggunakan neraca pegas sebagai alat daya pengukur. Neraca pegas boleh mengukur kuasa maksimum 100 N.

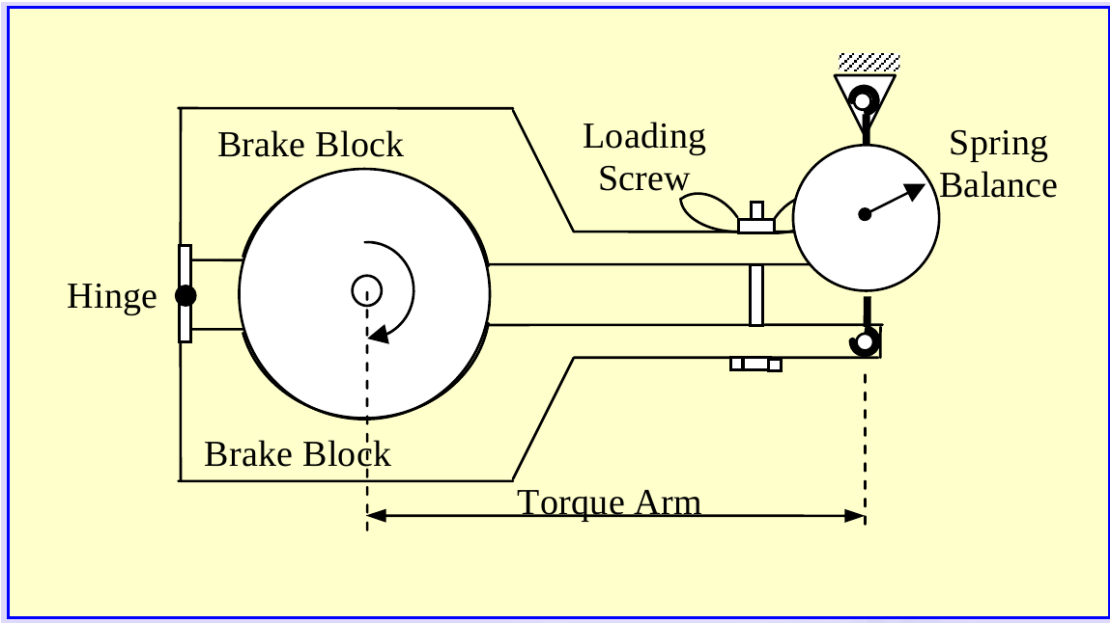


Figure 6(b)

Rajah 6(b)

(i) Explain the operation mechanism

Terangkan mekanisma operasi

(ii) Determine the proper torque arm for dynamometer

Tentukan lengan tork yang sesuai untuk dynamometer

(40 marks/*markah*)

(c) In a gear box transmission dynamometer, the input and ouput shafts are co-axial and rotate in the same direction at speeds of 1600 and 400 rpm, respectively. An external torque is applied to the casing to prevent it from rotating using a mass of 120 kg at a distance of 30 cm from the axis. The overall mechanical efficiency is 90%. Find the power at the input shaft.

Dalam dinamometer penghantaran kotak gear, masukkan dan keluaran aci adalah bersama-paksi dan masing-masing berputar dalam arah yang sama pada kelajuan 1600 rpm dan 400 rpm. Satu tork luaran digunakan untuk selongsong untuk menghalangnya daripada berputar menggunakan jisim 120 kg pada jarak 30 cm dari paksi. Kecekapan mekanik keseluruhan ialah 90%. Cari kuasa pada aci masukan.

(30 marks/*markah*)

-oooOooo-