UNIVERSITI SAINS MALAYSIA

First Semester Examination
Academic Session 2008/2009
Peperiksaan Semester Pertama
Sidang Akademik 2008/2009

November 2008
November 2008

EMM 401/3 – Instrumentations System
Sistem Peralatan

Duration : 3 hours
Masa : 3 jam

INSTRUCTIONS TO CANDIDATE:
ARAHAN KEPADA CALON:

Please check that this paper contains **THIRTEEN (13)** printed pages and **TEN (10)** questions before you begin the examination.
*Sila pastikan bahawa kertas soalan ini mengandungi **TIGA BELAS (13)** mukasurat dan **SEPULUH (10)** soalan yang bercetak sebelum anda memulakan peperiksaan.*

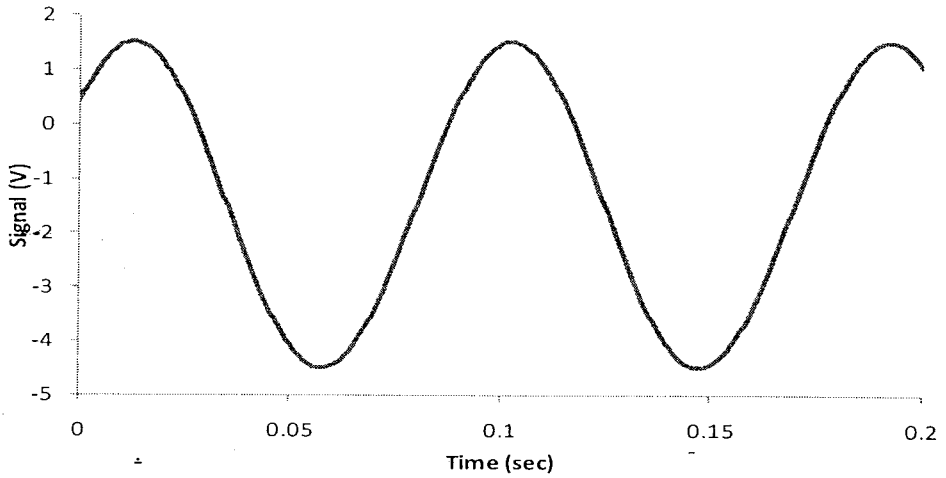
Answer **ALL** questions.
*Jawab **SEMUA** soalan.*

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] Write the equation of the following sinusoidal signal:

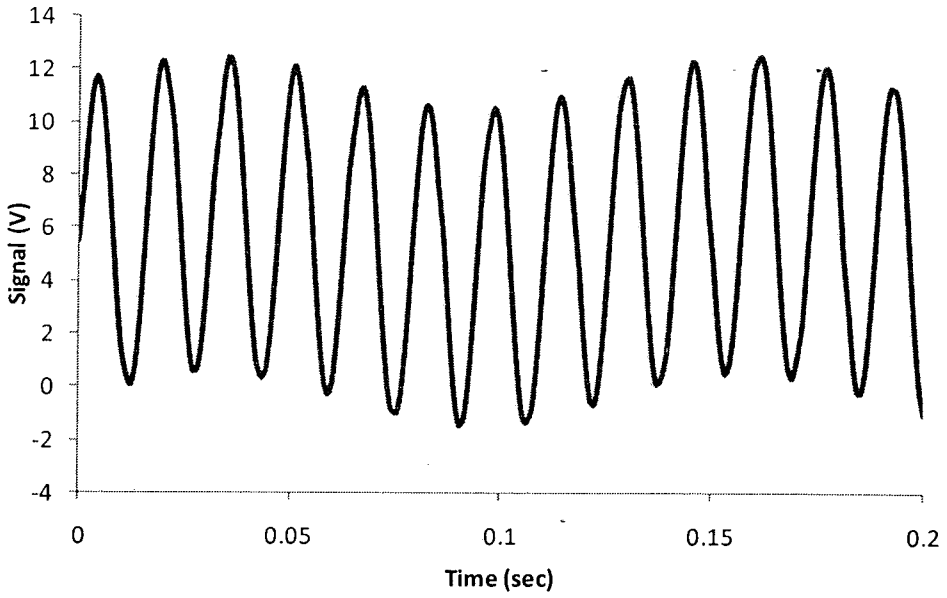
Tuliskan persamaan untuk isyarat sinus berikut:



(15 marks/*markah*)

[b] Given the following curve, draw the approximate spectrum. Label all axes and provide a scale.

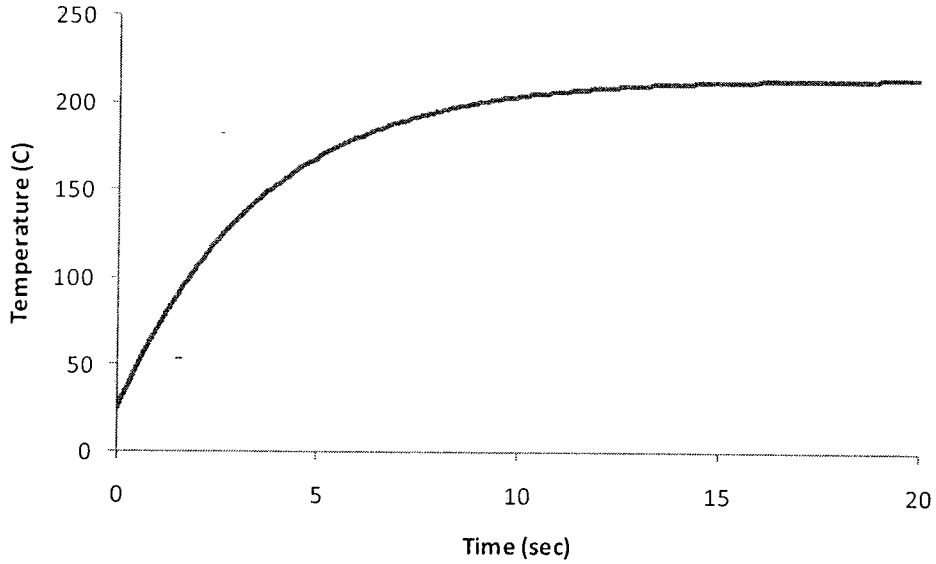
Diberikan lengkung berikut, lukis spektrum yang sesuai. Labelkan semua paksi dan berikan skala.



(25 marks/*markah*)

Q2. [a] A thermocouple is immersed in hot oil at time t = 0 and yields the following data:

Suatu pengganding suhu direndam ke dalam minyak panas pada masa t = 0 dan menghasilkan data berikut:



Assuming the response is that of a 1st order system: What is the time constant?

Write the equation for the temperature of the thermocouple after immersion in the oil.

If the thermocouple is subsequently removed from the oil and placed immediately in propylene glycol (similar to oil) at -45°C, how long will it take to cool (or heat up?) to 100°C?

Dengan mengandaikan bahawa sambutan adalah sama seperti sistem tertib 1, apakah pemalar masa?

Tuliskan persamaan bagi suhu pengganding suhu selepas direndam di dalam minyak.

Jika pengganding suhu tersebut kemudian dikeluarkan daripada minyak dan diletakkan dengan serta merta di dalam 'propylene glycol' (serupa dengan minyak) pada -45°C, berapa lamakah masa yang diambil untuk pengganding suhu menyejuk (atau memanas) kepada 100°C?

(30 marks/*markah*)

[b] **The equation for an under-damped 2nd order spring mass system is:**

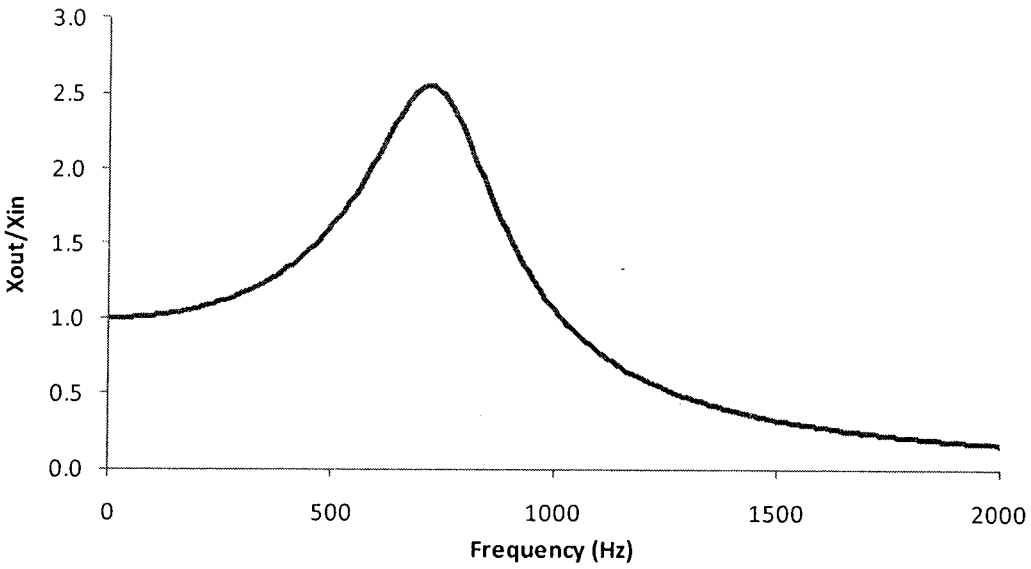
$$X_{out} / X_{in} = \frac{1}{[\,(1 - (w_f/w_n)^2)^2 + (2Zw_f/w_n)^2\,]^{1/2}}$$

The system has a spring stiffness of k =100 kN/m, and an unknown mass. The system exhibits the following dynamic response when subject to a 10 N sinusoidal forcing function:

Persamaan bagi sistem pegas-jisim tertib 2 terendam-kurang ialah:

$$X_{out} / X_{in} = \frac{1}{[\,(1 - (w_f/w_n)^2)^2 + (2Zw_f/w_n)^2\,]^{1/2}}$$

Sistem tersebut mempunyai kekakuan pegas k =100 kN/m, dan jisim yang tidak diketahui. Sistem tersebut menunjukkan sambutan dinamik berikut apabila dikenakan fungsi memaksa sinus 10 N:



(i) What is the mass (in grams)?

Apakah nilai jisim (dalam gram)?

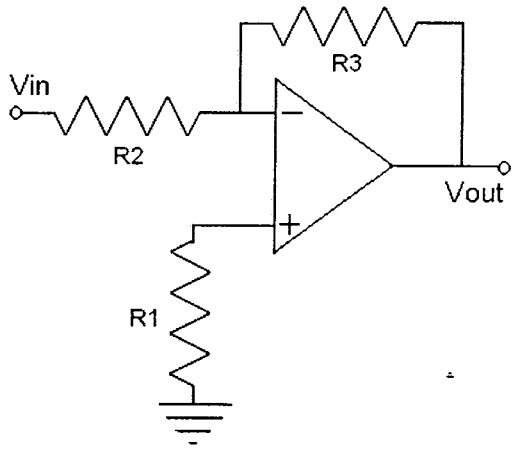
(ii) What is the coefficient of Dampening c?

Apakah nilai pekali redaman c?

(20 marks/*markah*)

Q3. [a] **The following op-amp is operating from a ±15 V power supply. R1 = 10 kΩ, R2 = 6 kΩ, R3 = 33 kΩ.**

Op-amp berikut beroperasi daripada bekalan kuasa ±15 V. R1 = 10 kΩ, R2 = 6 kΩ, R3 = 33 kΩ.



(i) **What is Vout for Vin = -1.5 V?**

Apakah nilai Vout bagi Vin = -1.5 V?

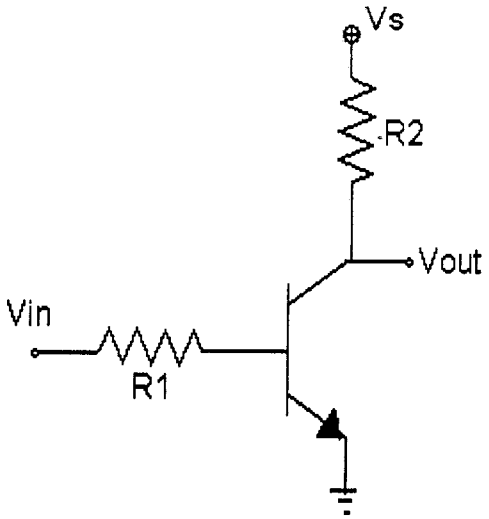
(ii) **What is Vout for Vin = +4.4 V?**

Apakah nilai Vout bagi Vin = +4.4 V?

(30 marks/*markah*)

[b] **For the given transistor circuit R1 = 10 kΩ, R2 = 5 kΩ, Vs = 12 V. The transistor has a current gain of hf = 75.**

Bagi litar transistor yang diberikan R1 = 10 kΩ, R2 = 5 kΩ, Vs = 12 V. Transistor tersebut mempunyai gandaan arus hf = 75.



(a) **Give the linear best fit curve in the range of 0.001 to 0.006 m^3/sec. Approximate if necessary.**

Berikan lengkung lelurus paling cocok dalam julat 0.001 hingga 0.006 m^3/saat. Anggarkan jika perlu.

(b) **What is the worst case error in your approximation (in l/sec) over the prescribed range?**

Apakah ralat kes paling buruk dalam anggaran anda (dalam l/saat) dalam julat yang dinyatakan?

(c) **The signal is read by a 0-10 V ADC. How many bits should the system have in order to have a resolution of better than 1% over the prescribed range?**

Isyarat tersebut dibaca oleh ADC 0-10 V. Berapakah bilangan bit yang perlu berada pada sistem supaya ia mempunyai resolusi lebih baik daripada 1% dalam julat yang dinyatakan.

(d) **What would your digital number be at 3 l/sec air flow rate?**

Apakah nombor digital anda pada kadar aliran udara 3 l/saat?

(e) **The ADC uses the successive approximation method to establish the value of each bit in the digital value successively. In order to yield an updated digital value every 250 ms, what is the minimum clock frequency (i.e. for each bit) the converter can have?**

ADC tersebut menggunakan kaedah penghampiran berturutan untuk menentukan nilai setiap bit dalam nilai digital secara berturutan. Untuk menghasilkan nilai digital yang terkini setiap 250 ms, apakah frekuensi jam minimum (i.e. bagi setiap bit) yang boleh ada pada penukar?

(f) **What would be the highest frequency air flow fluctuation this system would be sensitive to?**

Apakah frekuensi tertinggi turun-naik aliran udara yang sistem ini peka kepada?

(g) **Give an equation to convert the digital number to an air flow in liters/sec based on your linear approximation.**

Berikan suatu persamaan untuk menukarkan nombor digital kepada aliran udara dalam liter/saat berasakan penghamiran lelurus anda.

(100 marks/*markah*)

Q5. [a] **A digital position display for a milling machine requires 0.0001 inch resolution, and a 24 inch range (in the x-direction).**

Suatu pemapar kedudukan digital bagi mesin pengisar memerlukan resolusi 0.0001 inci, dan julat 24 inci (dalam arah-x).

(i) **If a 2-channel relative position encoder is used with quadrature decoding, what is the fringe size required for this resolution?**

Jika pengekod kedudukan relatif 2-saluran digunakan dengan pengekodan kuadrator, apakah saiz pinggir yang diperlukan bagi resolusi ini?

(ii) **How many bits are required to measure the whole range?**

Berapakah bilangan bit yang diperlukan untuk mengukur pada seluruh julat?

(iii) **If the maximum velocity of the stage is 2 inches/sec what is the maximum frequency of the signal from each channel?**

Jika halaju maksimum pelantar ialah 2 inci/saat apakah frekuensi maksimum isyarat setiap daripada setiap saluran.

(iv) **For a factor of safety of 2 what is the maximum rise time of the input gate of the counter be?**

Bagi faktor keselamatan 2 apakah masa naik maksimum bagi get input pengira?

(v) **If an absolute position encoder was used instead, how many bits would be required?**

Jika pengekod kedudukan mutlak digunakan, berapakah bilangan bit yang akan diperlukan?

(50 marks/*markah*)

[b] **A 17" diameter wheel with a single pulse per revolution speed pickup gives the following data:**

Roda bergarispusat 17" dengan pikap laju denyutan tunggal bagi setiap putaran memberikan data berikut:

Revolution	Time
1	150 ms
2	147 ms
3	145 ms

(i) **What is the vehicle speed [in km/hr] during the 1st revolution?**

Apakah kelajuan kenderaan (dalam km/jam) semasa putaran pertama?

(ii) **What is the vehicle speed [in km/hr] during the 2nd revolution?**

Apakah kelajuan kenderaan (dalam km/jam) semasa putaran kedua?

(iii) **What is the acceleration [in m/s²] of the vehicle from rev1 to rev3?**

Apakah pecutan kenderaan (dalam m/s²) dari putaran satu ke tiga?

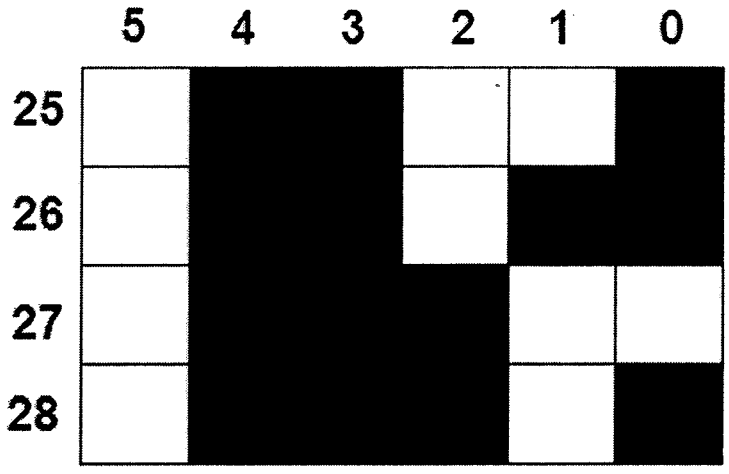
(iv) **How far did the vehicle travel [in m] from rev 1 to rev 3?**

Apakah jarak lintasan kenderaan (dalam m) dari putaran satu ke tiga?

(50 marks/*markah*)

Q6. A 6 bit binary code indexer is used to measure the position of a linear stage. In the transition going from position 26 to position 27, what are the possible *incorrect* readings due to minor misalignment between the mask and the reader?

Suatu pengindeks kod binari 6-bit digunakan untuk mengukur kedudukan pelantar lelurus. Dalam peralihan dari kedudukan 26 ke kedudukan 27, apakah bacaan-bacaan salah yang mungkin didapati kerana salah jajaran antara topeng dengan pembaca?



(30 marks/*markah*)

Q7. **What are the common electronic ways of measuring displacement? List as many as possible. Give their advantages and disadvantages and rank their relative bandwidth.**

Apakah cara-cara elektronik yang lazim untuk mengukur anjakan? Senaraikan beberapa banyak yang mungkin. Berikan kelebihan dan kelemahan setiap cara dan susunkan lebar jalur relatifnya.

Sensor *(Sensor)*	**Advantages** *(Kelebihan)*	**Disadvantages** *(Kelemahan)*	**Bandwidth** *(Lebar jalur)*
1			
2			
3			
4			
5			
6			
7			
8			

(40 marks/*markah*)

Q8. **An automotive air bag system uses an accelerometer with a sensitivity of 2 mV/g in a circuit as shown. R1 = 10 kΩ, R2 = 2 kΩ, R3 = 20 kΩ.**

Sistem beg udara sebuah otomotif menggunakan meter pecutan dengan kepekaan 2 mV/g di dalam litar yang ditunjukkan. R1 = 10 kΩ, R2 = 2 kΩ, R3 = 20 kΩ.

(a) **What is the gain of the first (left) amplifier?**

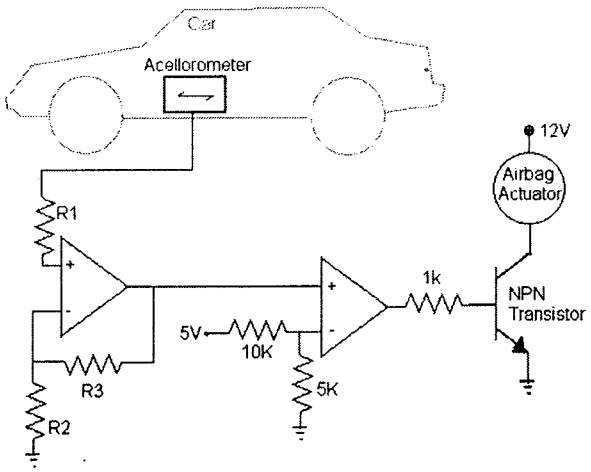
Apakah gandaan penguat pertama (kiri)?

(b) **What is the reference voltage (V-) of the comparator?**

Apakah voltan rujukan (V-) bagi pembanding?

(c) **At what acceleration level (m/s^2) will the air bag system be triggered?**

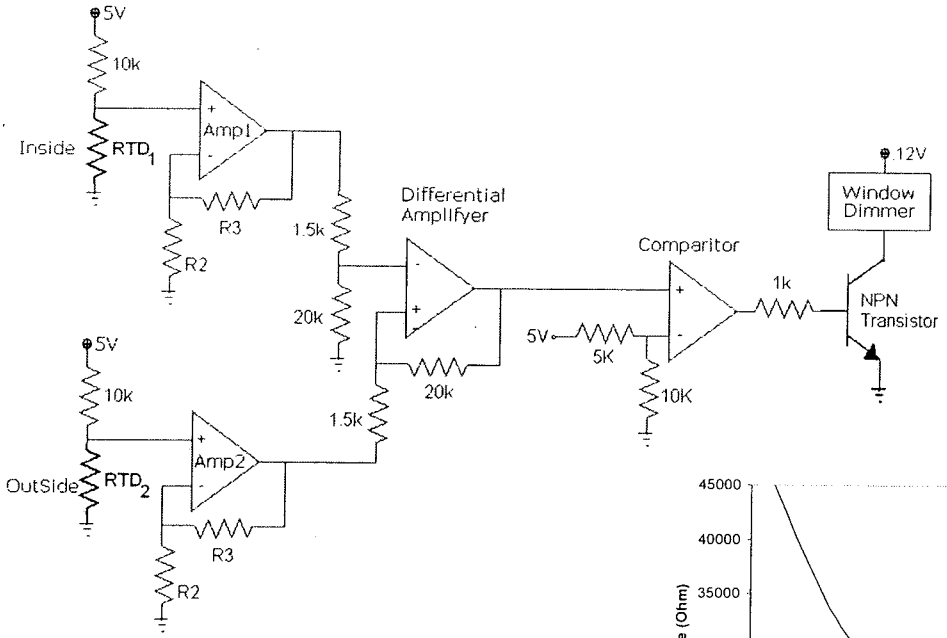
Pada paras pecutan berapakah sistem beg udara akan dipicu?

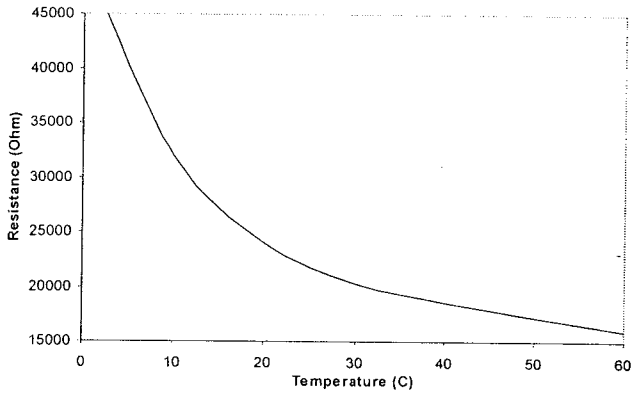


(100 marks/*markah*)

Q9. **A temperature control system measures the inside and outside temperatures of a house using the following circuit. The temperature response of the RTDs are identical, and given in the accompanying graph. R2 = 5 kΩ, R3 = 2 kΩ.**

Sistem kawalan suhu mengukur suhu di luar dan di dalam sebuah rumah dengan menggunakan litar berikut. Sambutan suhu RTD adalah sama, dan diberikan dalam graf yang diiringi. R2 = 5 kΩ, R3 = 2 kΩ.





(a) **What is the gain of Amp1 and Amp2?**

Apakah gandaan Amp 1 dan Amp2?

(b) **What is the gain of the differential amplifier?**

Apakah gandaan penguat kebezaan?

(c) **What is the reference voltage (V-) of the comparator?**

Apakah nilai voltan rujukan (V-) bagi pembanding tersebut?

(d) **Assuming the inside temperature is approximately 25°C, what voltage will be required at the output of Amp2 to actuate the window dimmer?**

Dengan mengandaikan bahawa suhu dalam ialah lebih kurang 25°C, apakah voltan yang diperlukan pada output Amp2 untuk mengacu seluruh 'dimmer' tingkap?

(e) What is the corresponding outside temperature?

Apakah suhu luar yang sepadan?

(100 marks/*markah*)

Q10. Fuel consumption is measured by weighing a 5 liter fuel tank as an engine consumes fuel. The density of the fuel is 720 gm/liter. R1 and R2 are 350 ohm metal foil strain gages with a gage factor of 2. The balancing resistor (Rbal) is adjusted so that Vout is 0 when the fuel tank is empty. Young's modulus (E) for the cantilever is 200 GPa, and the dimensions are Length (to center of tank) = 40cm, Width = 1.5 cm, and Thickness = 0.5 cm.

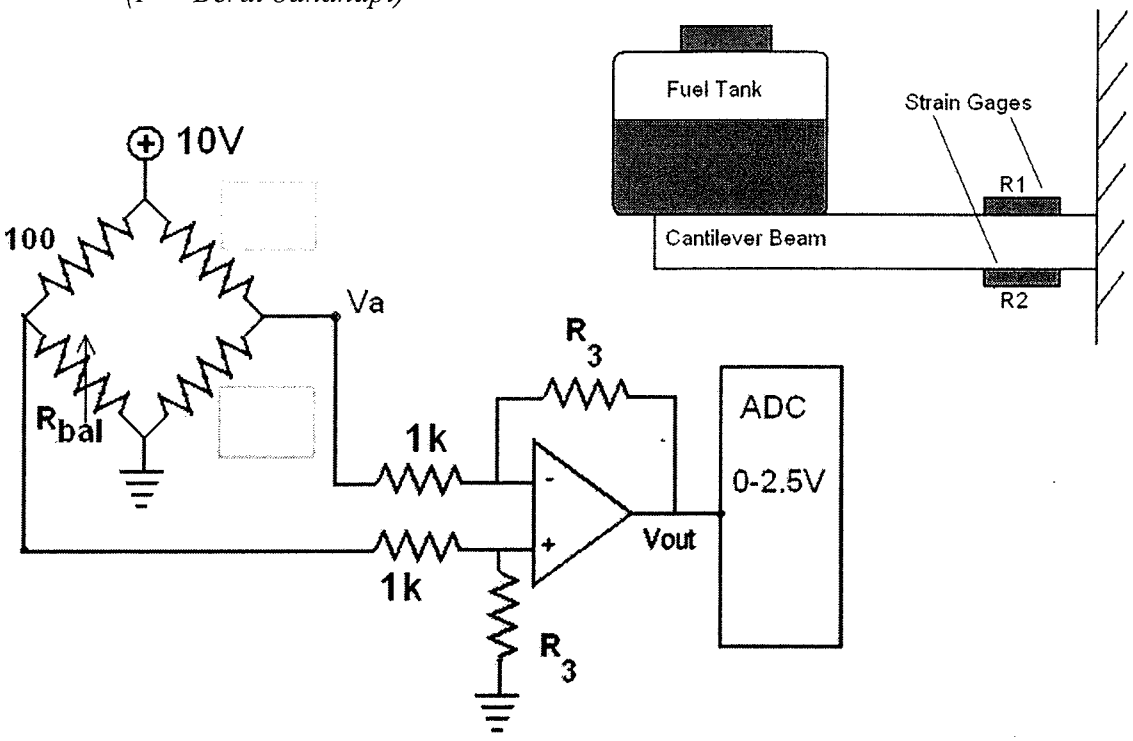
Surface Stress: $\sigma = \frac{24\,LF}{TW}$ $E = \sigma / \varepsilon$

(F = Weight of fuel)

Penggunaan bahanapi diukur dengan menimbang tangki bahanapi 5 liter semasa enjin menggunakan bahanapi. Ketumpatan bahanapi ialah 720 gm/liter. R1 dan R2 ialah tolok-tolok terikan kerajang logam dengan faktor tolok 2. Perintang mengimbang (Rbal) dilaraskan supaya Vout ialah 0 apabila tangki adalah kosong. Modulus Young (E) bagi rasuk julur ialah 200 GPa, dan dimensi-dimensi adalah: Panjang (ke pusat tangki) = 40 sm, Lebar = 1.5 sm dan Ketebalan = 0.5 sm.

Tegasan permukaan: $\sigma = \frac{24\,LF}{TW}$ $E = \sigma / \varepsilon$

(F = Berat bahanapi)



(a) **Label the 2 resistors (R1 and R2) in the bridge so that the voltage Vout will go up as fuel is added.**

Labelkan kedua-dua perintang (R1 dan R2) di dalam tetimbang supaya voltan Vout akan meningkat semasa bahanapi ditambahkan.

(b) **What is the force F caused by 5 liters of fuel?**

Apakah daya F yang disebabkan oleh bahanapi sebanyak 5 liter?

(c) **What is the stress due to the fuel?**

Apakah tegasan yang disebabkan oleh bahanapi?

(d) **What is the change in resistance of the strain gages?**

Apakah perubahan dalam rintangan tolok-tolok terikan?

(e) **Using just the change in resistance from the weight of the fuel, what is the voltage Va when loaded with 5 liters of fuel?**

Dengan menggunakan hanya perubahan rintangan akibat berat bahanapi, apakah nilai voltan Va apabila dibebankan dengan 5 liter bahanapi?

(f) **Calculate R3 so that Vout will be 500 mV when the scale is full (5 liters of fuel).**

Kira R3 supaya Vout ialah 500 mV apabila skala penuh (bahanapi sebanyak 5 liter).

(g) **If the ADC has 16 bits what is the resolution in terms of grams of fuel?**

Jika ADC mempunyai 16 bit, apakah resolusi dalam sebutan gram bahanapi?

(h) **For a minimum fuel consumption rate of 1.5 gm/sec how long will we have to measure fuel consumption to get an error of less than 1% based on the weight resolution of the system?**

Bagi kadar penggunaan bahanapi sebanyak 1.5 gm/saat, berapa lamakah kita perlu mengukur penggunaan bahanapi untuk mendapat ralat kurang daripada 1% berasaskan resolusi berat bagi sistem tersebut?

(100 marks/*markah*)

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