University of Saskatchewan
College of Engineering
Department of Mechanical Engineering

ME 318.3 Laboratory I - Term Examination

Time: 3 Hours **December 5, 2005**

Lab Manuals and Log Books Permitted

Name: _____

Student Number: _____

Signature: _____

- Please print your name at the top of each answer sheet.
- Please answer each question in the space provided. You may use the back of each sheet if required. The lab numbers corresponding to each question are indicated.

Faculty	Question	Marks	SCORE
Fotouhi	1- S1	7	
Larson	2- S2	6	
Dolovich	3- S3	7	
Larson	4- S4	7	
Szyszkowski	5- S5	7	
Adigun	6- E1	6	
Adigun	7- E2	6	
Steinmetz	8- M1 & M2	12	
Chen	9- M3	7	
Sumner	10- H1	5	
Burton	11- H2	7	
Simonson	12- H3	7	
Larson	13- H4	8	
Simonson	14- H5	8	
	TOTAL	100	

Room: 1A76 Engineering
Co-ordinators: P.B. Hertz & C. James

Question 1 – S1 **(7 marks)**

A strain gauge manufacturer has determined the gauge factor of a particular strain gauge by means of a tension test, without bending and at a constant temperature, to be F=2.25 ($\nu_o = 0.29$).

The gauge has a nominal resistance of 120 Ω and a transverse sensitivity factor of $K_t = 0.04$. It is mounted along the axial direction of a steel specimen possessing a Poisson's ratio of 0.29.

(a) What change in the measurement of resistance of the gauge is expected, when the axial strain in the specimen is 1100 μ in/in?

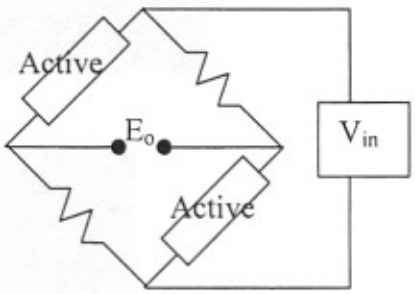
(b) If this gauge is mounted on the following specimen and be used in a bending test (Cantilever beam experiment), what would you expect to see as measured strain in strain gauge reading, if this gauge is used in a specimen with a Poisson's ratio of 0.35? (Modulus of Elasticity $E = 10.6 \times 10^6$ psi, length 6.00in, width 1.00in, thickness 0.125in, W = 4.50 lb, assume adhesive thickness is zero)

Question 2 – S2 **(6 marks)**

This data was obtained from a tensile test of a steel specimen (E=200GPa) using the Wheatstone bridge circuit shown below. The active gauges were mounted on diametrically opposite sides of a cylindrical specimen of diameter, D = 12.57mm.

The indicated strain has been divided by 2 in the table below. Assume that no bending moment was present. Slope of the strain-load plot is given.

Load (N)	½ e_c (μ in/in)
2000	106
4000	187
6000	267
8000	348
slope	0.0403

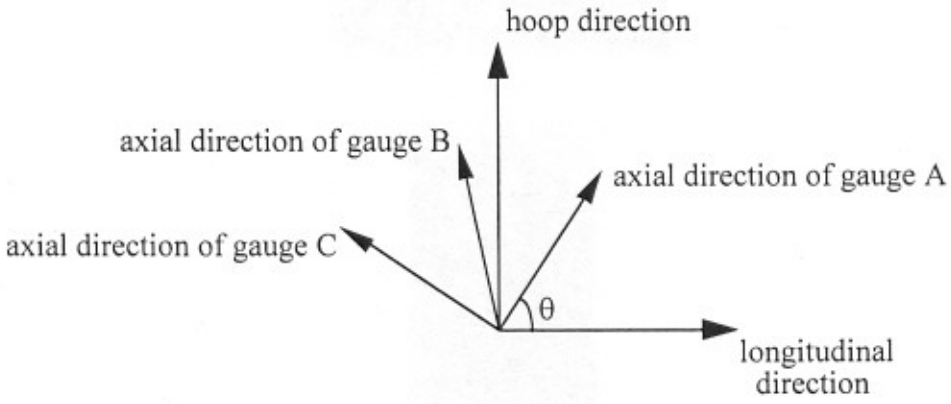


(a) Considering the circuit only, show that the signal is amplified and that no temperature compensation is provided.

(b) For the 8 kN load, determine the change in resistance due to the uncompensated temperature change in the strain gauges. Properties of the strain gauges:
Resistance of 120 Ω
Gauge Factor of 2.1

Question 3 – S3 **(7 marks)**

A rectangular strain gauge rosette is mounted on a closed thin-walled cylinder which is pressurized to 500 psi. The cylinder is made of a material for which the modulus of elasticity is 30×10^6 psi and Poisson's ratio is 0.3. The orientation of the three gauges, relative to the longitudinal and hoop directions, is shown below.

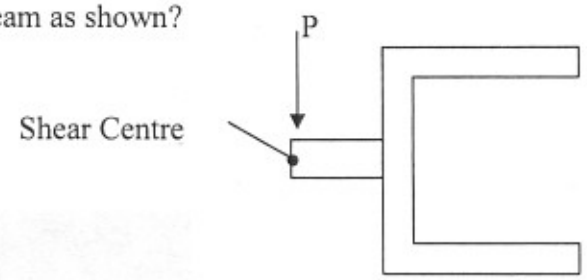


Gauge B is oriented 45° counterclockwise from gauge A, and gauge C is oriented 45° counterclockwise from gauge B. The measured strains are 212μ, 277μ, and 138μ for gauges A, B, and C, respectively.

Using the measured strain values and Mohr's circle, calculate the principal strains at the rosette. Calculate the angle, θ, between gauge A and the longitudinal direction. (Assume that $\varepsilon_1 = \varepsilon_{hoop}$ and $\varepsilon_2 = \varepsilon_{long}$.)

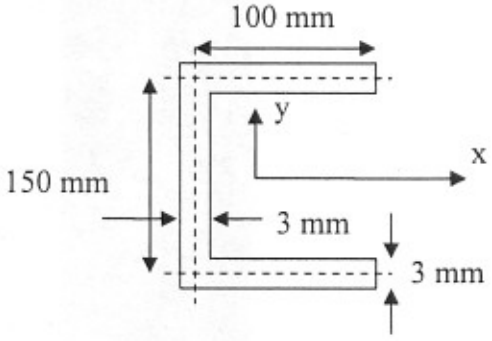
Question 4 – S4 **(7 marks)**

(a) What is the advantage of loading a beam as shown?



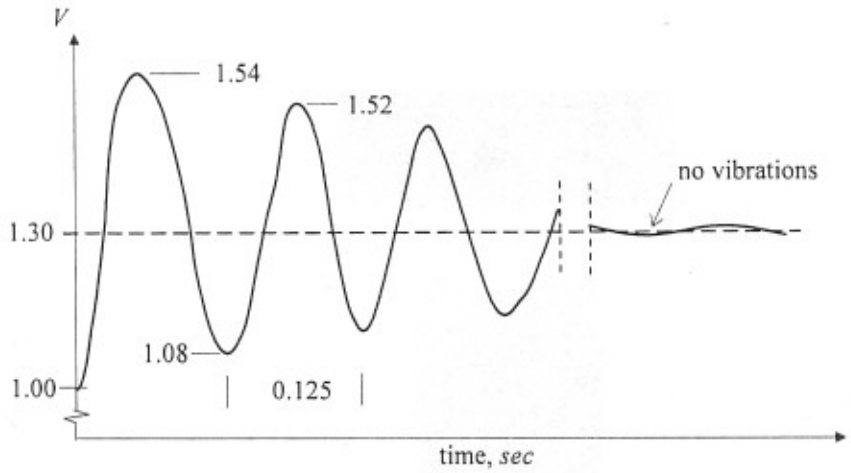
(b) Determine the location of the shear centre (e) for the beam shown below and show its position.

$e = c^2d^2t / 4I_{xx}$



Question 5 – S5 **(7 marks)**

The response sketched (not to scale) below (the numbers represent either volts or seconds) is observed on the oscilloscope if a mass M is dropped from some height h on the beam's end.



Use the plot to determine:

(a) The maximum 'dynamic' stress in the beam. When the vibrations die out (or if M was placed 'statically' on the beam) the maximum stress is $100MPa$.

(b) The frequency of vibration (in Hz). How this frequency would be affected if:

(i) mass M was dropped from height $2 \times h$,

(ii) mass $2 \times M$ was dropped from height h.

(c) The damping ratio ξ. Estimate the reduction in the amplitude of vibration after 30 cycles.

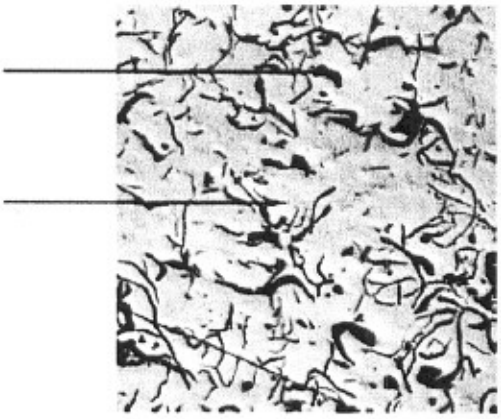
Question 6 – E1 **(6 marks)**

(a) What are the phases that are likely to be found in 0.9 wt% C steel that was heated to a temperature of 1200°C and slowly cooled to room temperature?

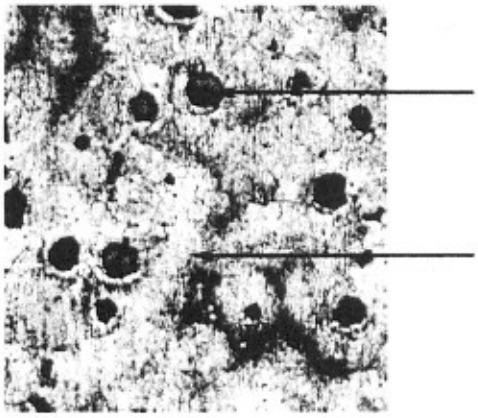
(b) When steel is rapidly cooled from 1400°C to 150°C, explain what happens to the grain size and what are the effects on mechanical properties?

Question 7 – E2 **(6 marks)**

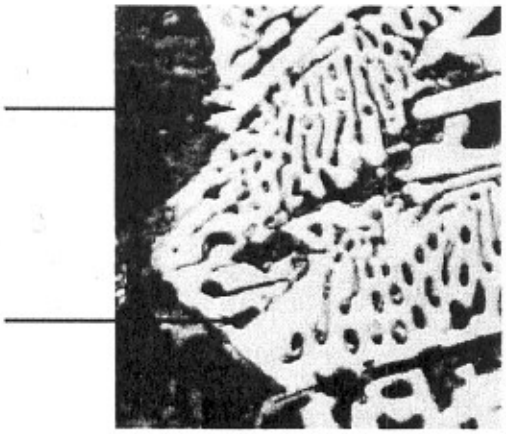
(a) Identify the two indicated phases shown in each of these micrographs:



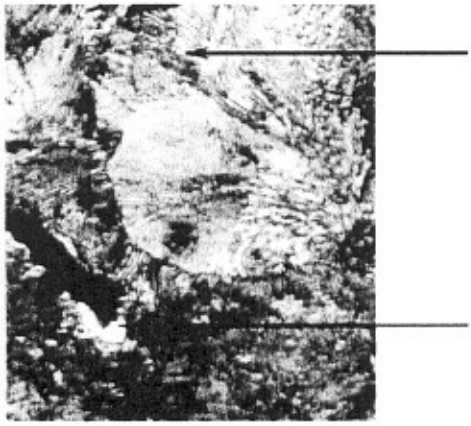
A



B



C



D

(b) How can one use weight percent of carbon to differentiate between cast iron and steel?

Question 8 – M1 & M2 **(12 marks)**

(a) The milling machine is the most versatile of all machine tools. What machining operations can be done on a milling machine? Name at least 4 operations. (**2 marks**)

(b) How are lathe tools set up for operations? (**1 mark**)

(c) How can tool life can be prolonged? Name at least 3 preventive measures. (**2 marks**)

(d) Describe the fundamental difference between a lathe and a milling machine. (**2 marks**)

(e) What is the pitch of a micrometer spindle if the micrometer measures only inches. (**2 marks**)

(f) A new lathe with variable speed is used on cast iron work with a 150 mm diameter to make a 200 mm long cut in 4 passes. The operation conditions listed below were provided by the supplier or assumed. Calculate the total cutting time (min). (**3 marks**)

Given: Cutting speed = 120 m/min
Feed Rate = 0.25 mm/rev.

Question 9 – M3 **(7 marks)**

A metal is deformed in a tension test into its plastic region. The starting specimen had a gauge length = 50.0 mm and a diameter of 12.0 mm. At one point in the tensile test, the load = 60 kN and the corresponding gauge length = 51.50 mm. Determine

(a) the diameter of the specimen at the above load,

(b) the true stress and strain at the above load, and

(c) the strain hardening exponent (n) for this metal if at another point in the test prior to necking, the gauge length = 53.20 mm and the corresponding engineering stress = 574.73 MPa.

Question 10 – H1 **(5 marks)**

A certain thermometer has a time constant of 15 s and an initial temperature of 20°C. It is suddenly exposed to a temperature of 100°C.

Determine (i) the rise time, i.e. the time to attain 90% of the steady-state value, and (ii) the temperature at this time.

Suggest two ways to reduce the time constant of this instrument by 50%.

Question 11 – H2 **(7 marks)**

A sensor is used to measure the temperature of a system. The voltage output of the sensor is Vo = ±5mV, and the signal frequency = 1000Hz. The signal is monitored by a DAQ system.

(a) Provide a short description of a typical data acquisition system used for the above situation.

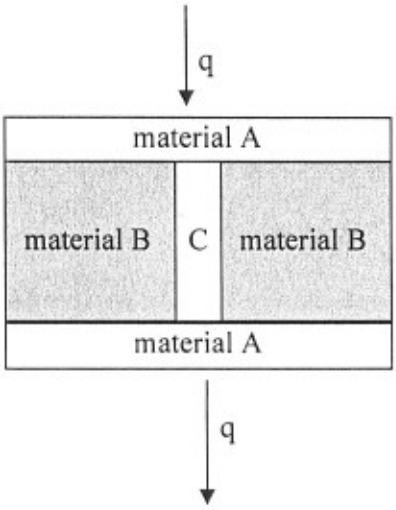
(b) The range on the DAQ system is ±10V. If the gain of the system can be set from 0 to 5000 in increments of 1000, select an appropriate gain.

(c) A choice must be made between a 3, 8 and 16 bit DAQ system. Choose an appropriate bit rate if the system is limited in memory and speed.

(d) If the signal from the sensor is contaminated with a noise of F = 3999Hz, and a minimum sampling frequency on original signal is used, determine the resulting effects and suggest a remedy.

Question 12 – H3 **(7 marks)**

A composite wall is constructed with materials that have properties as shown below. Determine the resistance of the wall using the two different methods taught in lab H3.

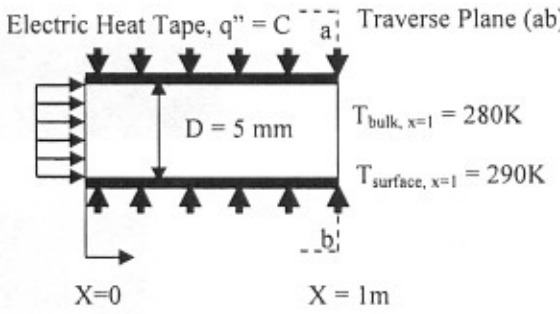


Material	k [W/(m·K)]	Thickness [mm]	Area [m^2]
A	0.1	5	1
B	0.05	20	0.8
C	0.3	20	0.2

Question 13 – H4 **(8 marks)**

Freon is flowing through a pipe with a constant heat flux. The heat flux is provided by electrical heat tape which covers the entire surface area. The heat lost to the atmosphere is 1 W and conduction in the pipe is negligible. The velocity and temperature profiles are both uniform at the inlet. From a traverse of the pipe at 1 m the bulk temperature (280K) and Reynolds Number (2000) were determined.

Property	Value	Unit
Heat Tape Voltage input	12	V
Heat Tape Current	1.2	Amps
q_{losses}	1	W
k_{freon}	0.073	W/(m K)
Pr_{freon}	3.5	-
Reynolds (at Traverse)	2000	-



For Laminar Flow $\frac{x_{fd,thermal}}{D} = 0.05\,Re\,Pr$ and for turbulent flow $\frac{x_{fd,thermal}}{D} > 10$

(a) SKETCH the velocity and thermal profiles at the traverse plane.

(b) Determine the convective heat transfer coefficient at the transverse plane.

(c) Choose the best correlation from the list below, calculate the convective heat transfer coefficient and compare the result to part b.

Correlations:

$Nu_D = 1.953\left(Re\,Pr\,D/L\right)^{1/3}$	Hydrodynamically developed, thermally developing, laminar flow $Re\,Pr\,D/L \geq 33.3$
$Nu_D = 0.023\,Re_D^{4/5}\,Pr^{0.4}$	Hydrodynamically developed, thermally developed, Turbulent flow $120 \geq Pr \geq 0.7$
$Nu_D = 4.36$	Hydrodynamically developed, thermally developed, laminar flow
$Nu_D = 3.657 + \frac{0.0677\left(Re\,Pr\,D/L\right)^{1.33}}{1+0.1\,Pr\left(Re\,D/L\right)^{0.3}}$	Hydrodynamically developing, thermally developing, laminar flow $7 \geq Pr \geq 0.7$ and constant wall temperature

Question 14 – H5 **(8 marks)**

For the measurements given below on a parallel flow heat exchanger, calculate the effectiveness of the heat exchanger and the uncertainty in the effectiveness. Assume the uncertainty is negligible if no uncertainty value is given.