UNIVERSITY OF BRITISH COLUMBIA
DEPARTMENT OF MECHANICAL ENGINEERING

QUIZ 6. Wednesday November 9, 2016

MECH 221

READ THESE INSTRUCTIONS CAREFULLY BEFORE BEGINNING THE QUIZ. GOOD LUCK!

Duration: Target = 45 minutes. Maximum = 50 minutes.

Materials admitted: Pencil, eraser, straightedge, Mech2 calculator, Mech2 formula book, one 3x5 inch index card.

There are five short-answer questions and two long-answer questions. ***All questions must be answered.***

Provide **all** work and solutions **on these test pages**. Scrap paper is available for your use, but **will not be collected or marked**. An additional mark of up to 5% of the exam value is available for orderly presentation of work

Illegible work, or answers that do not include supporting calculations and explanations will NOT be marked.

BE SURE TO WRITE YOUR NAME ON THE TOP OF ALL EXAM PAGES

NAME:_____Section_____

SIGNATURE:_____

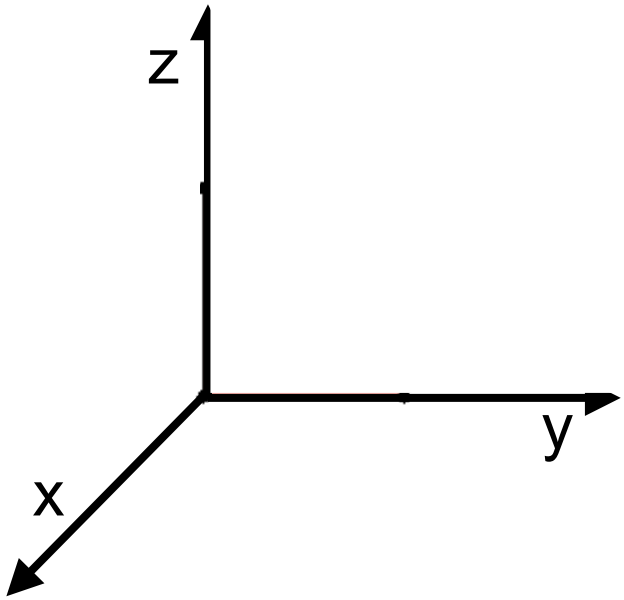
STUDENT NUMBER:_____

Question	Mark Received	Maximum Mark
SA 1		6
SA 2		6
SA 3		7
SA 4		6
LA 1		25
LA 1		
Presentation		
TOTAL		

Name:_____ Section:_____

Part I.

SA 1.



In the unit cell above, sketch the $(1\bar{1}0)$ plane.

If the crystal was body centre cubic, sketch the position of the atoms on the $(1\bar{1}0)$ plane assuming a hard sphere model.

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SA 2. Given that iron (Fe) has a body centered cubic crystal, a density of 7.86 $g.cm^{-3}$ and a molecular weight of 55.8 $gmol^{-1}$, determine the diameter of an iron atom (assume hard sphere model). Please report the diameter in the unit of nm.

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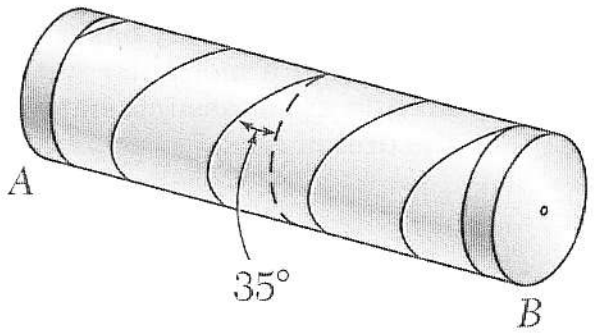
SA 3. A thin-walled cylinder of length L, diameter D, wall thickness t and interior pressure p is made by rolling and welding a plate into a 35° spiral, as shown. Derive a compact formula for the stress normal to the weld.



Name:_____ Section:_____

SA 4. Why do we use safety factors ? What issues do we typically need to consider when choosing an appropriate safety factor ?

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Part II.

LA 1. A long cylinder made of 4140 steel (Length = 5 m, diameter = 1 m, wall thickness = 10 mm, E = 210 GPa, ν = 0.3, yield stress = 1000 MPa) was designed to store nitrogen gas. After the cylinder was filled with gas it was noticed that the interior pressure gradually decreased. So that enough nitrogen gas would remain in the cylinder when needed, it was decided to add some more nitrogen in the cylinder by increasing the initial pressure. However, during this filling, the cylinder exploded at a pressure of 15,000 kPa. (No people or animals were injured in the construction of this question). A subsequent investigation revealed that there had initially been two through-thickness cracks, one parallel to the length of the cylinder with a total length 20 mm and one parallel to the circumference of the cylinder with a total length of 40 mm.

i. Sketch the cylinder before it fractured.

ii. Did the material of the cylinder yield ? Explain your reasoning.

iii. Determine which of the cracks was most likely to have been the fracture initiation site. You may assume that Y=1.

iv. Estimate the fracture toughness, K_{Ic} , of the steel (in units of $MPa\sqrt{m}$)

v. The steel used in the cylinder was strengthened by a combination of deformation at room temperature (strain hardening, reducing the grain size of the steel and solid solution hardening. Explain the basic principles that cause these mechanisms to strengthen the steel.

vi. Calculate the changes in length and diameter of the cylinder just before it had exploded.

Name:_____ Section:_____

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