National Exams May 2009

07-Mec-B1, Advanced Machine Design

3 hours duration

Notes

1. Answer all questions of Part I (i.e., Questions 1 & 2) and only TWO questions from Part II of the examination.
2. Make sure your answers are neat; write your equations in symbol form first and put intermediate and final results in boxes.
3. State all assumptions clearly. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.
4. All answers must be clearly annotated with a summary of the approach, method, and results written in clear and correct English.
5. This is an OPEN BOOK EXAM.
6. Any non-communicating calculator is permitted.
7. Assume any missing data and make sure to properly state it in your answer.
8. The examination marks total 100.
9. Failure to follow the above directions will result in the grade penalties.

Part I

Questions 1 and 2 must be solved by all students.

Question 1 (25 points)

Mechanical engineering offers an environmentally-friendly method of energy storage: the flywheel. Consider the design of a flywheel powered road vehicle such as the *gyrobus* used in Yverdon, Switzerland in the 1950's. You are asked to develop a concept for a 1,200 kg four person sedan that could travel a minimum of 50 km on flywheel-power alone.

a) Estimate the energy required for the minimum trip.
b) Design a flywheel. Provide a sketch and specifications including a material. It must fit within an envelope of 500 mm × 500 mm × 1000 mm. Keep mass to a minimum.
c) What is the maximum energy the flywheel could contain without breaking the shaft?
d) Explain the problem that the flywheel presents to vehicle handling.

Question 2 (25 points)

Select a material based on its stiffness. In the table below, sample data is given for three species of trees, T1, T2, and T3. Each column in the table contains 20 tests done on individual trees from each species. The numbers are in GPa. Which tree will yield the highest stiffness for 95% probability?

	T1	T2	T3
1	13.9	10.8	9.7
2	13.8	10.9	9.6
3	13.1	10.7	9.5
4	12.9	10.6	9.6
5	12.7	10.6	9.6
6	14.0	10.8	9.0
7	13.9	10.8	9.2
8	14.1	10.9	9.4
9	12.7	11.0	11.0
10	15.0	13.0	9.1
11	15.1	10.6	9.2
12	13.1	10.7	9.8
13	13.4	10.1	10.1
14	13.6	10.2	8.9
15	14.1	10.8	12.0
16	12.8	10.4	10.8
17	13.4	10.4	9.8
18	15.0	10.8	9.5
19	13.3	10.9	9.7
20	14.1	10.8	10.5

Part II

Solve only two questions from the following three questions (3, 4, and 5).

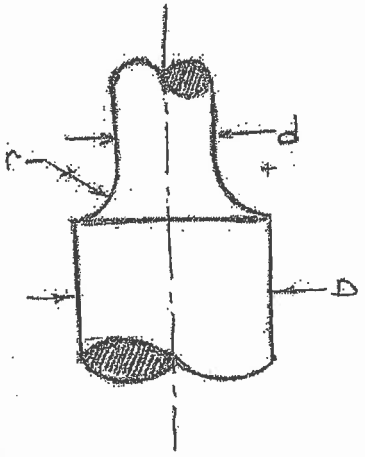
Question 3 (25 points)

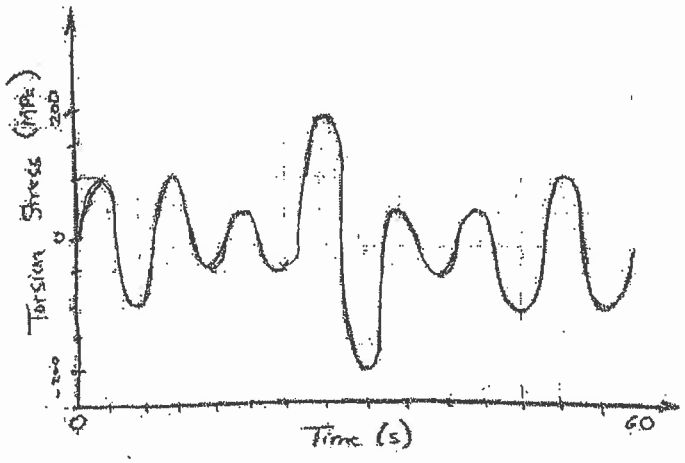
In your own words explain design details that may be employed to reduce corrosion for the following three situations.

a) In components that store or transfer liquids such as containers, baffles, and pipes where concentration cell corrosion may occur.
b) In the application of dissimilar materials in joints and fasteners leading to galvanic corrosion.
c) In structural members, corners, welded joints, and storage tanks subjected to atmospheric corrosion.

Question 4 (25 points)

In the diagram below, a machined steel shaft has specifications D = 100 mm, d = 50 mm, r = 5 mm, and 200 Bhn hardness. It is loaded with completely reversed torsion. The nominal stress for a typical 60 seconds of operation under overload conditions in the 50 mm diameter section is shown in the graph below. Estimate the life of the shaft when operating continuously under these conditions.





Question 5 (25 points)

In the diagram below, a 2.3 tonne weight is lowered down an incline of 45° to the horizontal by a steel cable at a constant speed of 1 m/s by a 550 mm radius drum weighing 5.4 kN with a 520 mm radius of gyration. The coefficient of kinetic friction between the weight and surface is 0.1. What additional torque must be applied by a brake on the drum to maintain the speed of the weight?