UNIVERSITY OF TORONTO
FACULTY OF APPLIED SCIENCE AND ENGINEERING
MIE442S – Machine Design
FINAL EXAMINATION, April 2001
Examiner: Professor J.K. Spelt

Aids permitted: Course text, handwritten class notes, distributed solutions and data sheets.
NO OTHER MATERIALS ARE PERMITTED ON YOUR DESK
Any calculator may be used, but its memory must not contain information related to the course. Answer all 4 questions. Marks are shown in [ ].

1. [10] A latching mechanism has two steel surfaces that slide over each other a total distance of 60 mm each time the latch is operated. The total sliding contact area is 2 cm^2. The only known property of the steels is their ultimate tensile strengths: 800 MPa and 655 MPa. The sliding contact is lubricated only occasionally and experiences a compressive load of 100 N. It is estimated that the latch is operated 30 times per day, 365 days per year.
a) Estimate the wear rate of the steel in mm^3/year.
b) If the sliding contact area is increased to 4 cm^2, how does the wear rate change?

2. [15] The figure below shows a 2 in. diameter rotating shaft, cantilevered from a hub that is connected to another shaft (not shown). The shaft and hub are being rotated by a pulley that creates a constant transverse end load, P. The round shaft is made of machined steel (S_{ut} = 180 ksi) and will operate at 20°C in dry air. The radius of the connection with the hub is 0.2 in., producing a static stress concentration factor K_t = 2.5 (σ_{nom} based on shaft diam.).
a) With a reliability of 99.9% calculate the maximum end load, P, that will permit an infinite fatigue life with a safety factor of 2. The torque at the pulley may be neglected.
b) What is the maximum end load for a fatigue life of $5x10^4$ with a safety factor of 2 ?
c) Estimate the maximum load in part a) if the component is frequently wet with fresh water?
d) If the shaft is not rotating and the cyclic load P is fully reversed, for the same situation as in part a), calculate the maximum end load.