MSE 480/780 – Mid-Term Exam

Friday, February 26th, 2:45pm, Room 3170

Calculators may be used
No smartphones or other electronic devices may be used
One page (8.5" x 11", both sides) of handwritten notes is permitted
All writing must stop at or before 4:20pm and exam booklets handed in

Provide all final answers clearly and unambiguously in your exam booklet.

Total Marks: 50

This exam has 3 pages

Problem 1 (25 Marks)

A two-toothed milling cutter is being used in an up-milling operation involving two passes (a "roughing" pass followed by a "finishing" pass). Only the feed rate is changed between each pass (all other process parameters remain constant). Referring to the process geometry developed in the course, following are the parameters describing the machining operation. It may be assumed that the equivalent chip thickness (h_{eq}) is approximately equal to the feed per tooth (s_t) in each pass.

Depth of cut (a): 4.5mm
Entry angle (Φ_1): 0
Exit angle (Φ_2): $\pi/3$
Swept angle of cut (Φ_s): $\pi/3$ (i.e. one third-immersion)
Tool Radius (R): 15mm

Feed Per Revolution, Roughing Pass (s_1): 0.10 mm
Feed Per Revolution, Finishing Pass (s_2): 0.06 mm
Spindle Speed: 520 RPM
Cutting Force Constant (K_1): 1880 N/mm^2
Critical Chip Thickness (h*): 0.02 mm
Chip Flow Angle (Ψ_e): $\pi/4$

Part a (10 marks)

Plot (sketch) the corresponding cutting torque versus time for one complete revolution of the cutter (during the **roughing** pass only), clearly indicating the scale (and/or key values) of torque on your diagram.

Part b (10 marks)

The machining system's spindle has been instrumented to measure instantaneous values of axial force (Fz). Following are the **peak** values of axial force that were measured during the cutting operation described above:

Roughing Pass: Peak axial force (Fz) = 243 N

Finishing Pass: Peak axial force (Fz) = 222 N

Using this information, calculate the cutting force ratios (r_1, r_2) for the work material / cutting tool pair.

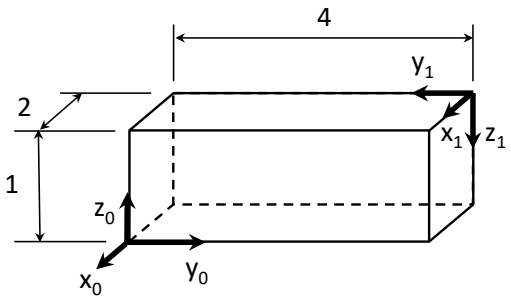
Part c (5 marks)

Ignore Part c (not covered in Spring 2018)

Problem 2 (25 Marks)

Part a (5 marks)

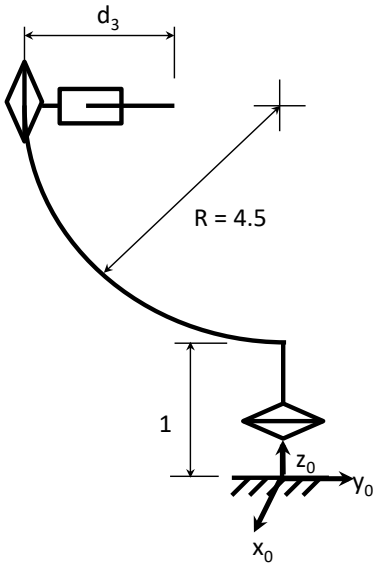
Consider the two frames (F_0, F_1) shown to the right, with the orientation and displacement between frames as illustrated. What is the corresponding homogeneous transformation A_{01}?



Part b (15 marks)

Consider the RRP manipulator shown to the right (with no end effector attached), which is part of an overall configuration used for sattelite assembly tasks. In the starting configuration with all joint variables equal to zero (as shown), all links rest within the y_0z_0 plane.

Making use of the world frame provided ($o_0x_0y_0z_0$), assign frames to the manipulator following the Denavit-Hartenberg (DH) convention. Clearly list the resulting table of DH parameters and develop the homogenous transformations A_{01}, A_{12} and A_{23}.



Part c (5 marks)

Assuming now that an end effector (gripper) is attached to the manipulator above as shown to the right (with the approach vector extending to the right and the normal vector directed out of the page), construct the final transformation matrix A_{3t}