Choose 3, and only 3, out of the following problems to work on.

1. A low-carbon steel material with shear yield strength of 400 MPa is cut on a lathe with a high speed steel tool under the following conditions:

cutting speed, V = 200 m/min
rake angle, α = 10 degrees
width of cut, w = 2 mm
undeformed chip thickness, t = 0.2 mm
mean coefficient of friction, μ = 0.5

Estimate the following quantities:

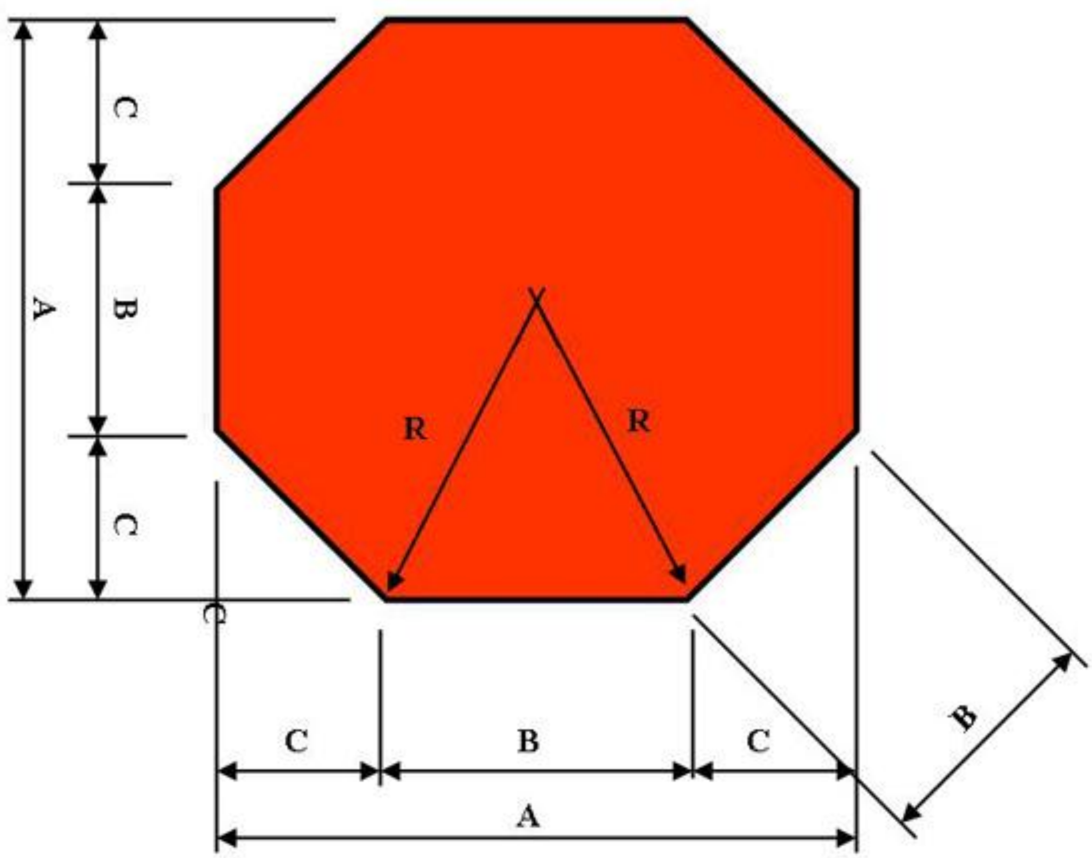
i. cutting ratio. List all assumptions involved in estimating this quantity.
ii. cutting force F_c
iii. thrust force F_t
iv. specific energies of shear and friction
v. mean temperature rise in the shear plane if 10% of the energy dissipated in the shear plane is conducted into the workpiece. List all assumptions you make in this calculation.

Where appropriate, use the following values for your calculations:

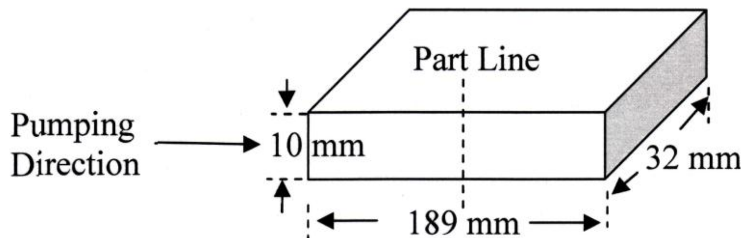
thermal conductivity of mild steel, k = 43.6 W/m-$^{\circ}$C
specific heat of mild steel, c = 502 J/kg-$^{\circ}$C
density of mild steel, ρ = 7200 kg/m^3

2. Consider the cold, direct extrusion of an octagonal rod of metal. Using an upper bound analysis, derive the extrusion pressure required.

The octagon has the geometry shown below. Form your answer in terms of the side length, *B*. The billet has initial length, *l*.



3. You are injection molding a polymer. The viscosity of the polymer is 1,350 N-s/m^2 at the processing temperature. The internal diameter of the barrel is 53 mm. Assume the barrel pitch is 60 mm. The pumping section of the screw is 2 m in axial length, with a flight width of 35 mm, and a flight depth of 6 mm. The polymer's glass transition temperature is 135 C, the mold is at 40 C and the polymer is injected at 220 C. The screw rotates at 87 rpm, when a shot is made. The mold's clamp generates a force of 770 kN. The back pressure is 689 kPa.



(a) Determine how long it will take to make a shot.

(b) What is the maximum injection pressure, based on the given part line in the figure above?

(c) From part (b), is this the best direction to open the mold? Why or why not, justify your answer?

4. You are sand casting magnesium into a bottom-gated mold to make a part that is a cylinder with a diameter of 25 cm and a height of 15 cm. The gate is cylindrical with a diameter of 0.5 cm. The pouring basin has a height of 4 cm. You may assume that the gate, the runner, and the bottom of the sprue have the same diameters. There should be no aspiration. Room temperature is 20^o C. Draw a sketch of the mold and label all the relevant features.

Determine the following:

(a) The solidification time, if the part is poured at 50ºC above its melting point. Explain whether this is an insulating or conducting mold situation.
(b) The combined height of the sprue and pouring basin, based on Reynolds number criterion (Re ≤20,000) and the avoidance of short shots (filling time less than pouring time).
(c) The diameter of the top of the sprue, based on “no aspiration” requirement.
(d) The entire time to cool from the pouring temperature to 100ºC, when it can be removed from the mold. Use h = 125 W/m^2-K for this part of the problem only.

Data for solid materials (room temperature)

Material	Specific heat (C) (kJ/kg-^{o}C)	Density (ρ) (kg/m^3)	Thermal conductivity (k) (W/m-^{o}C)
Sand	1.16	1500	0.60
Aluminum	0.90	2700	202
Nickel	0.44	8910	92
Magnesium	1.07	1700	156
Copper	0.39	8970	385
Gray cast iron	0.441	7125	42.7

Data for liquid materials

Material	Melting point (^{o}C)	Latent heat of solidification (fusion) (H_f) (kJ/kg)	Specific heat (C) (kJ/kg-^{o}C)	Viscosity (μ) (mPa-s)
Aluminum	660	396	1.05	1.3
Nickel	1453	297	0.73	--
Magnesium	650	384	1.38	1.04
Copper	1083	220	0.52	2.1
Gray cast iron	1251	211	0.34	5.25