Question #1

You wish to produce a torsion bar by twisting a shaft to a final angle, $\phi$, of 20°. The shaft has a length, $l$, of 0.1 m and a radius, $r$, of 0.01 m. The material is steel with an elastic modulus, $E$, of 200 GPa, a yield stress, $\sigma_y$, of 1000 MPa, and a Poisson's ratio, $\nu$, of 0.33. Determine the angle of twist that must be imparted to the shaft so, when released, the shaft will spring back to the correct angle.

Be sure to list all of your assumptions.

Question #2

A coated carbide cutter is used to machine a 2 inch diameter solid bar made of carbon steel in a single point turning configuration. From the tool post dynamometer the tangential cutting force and the thrust force can be measured to be 200 lb and 50 lb, respectively, when the radial depth of cut is 0.05 inch and the spindle speed is 600 rpm. The total machining time allocated for this job is 2 minutes to complete the cutting of a 7 inch long work-piece segment.

(1) Estimate the shear strength of the work piece material.
(2) Estimate the required total cutting and feeding power.
(3) Estimate the specific cutting energy of this work piece under this set of condition.
(4) Estimate the shear angle in this process.
(5) Estimate the friction coefficient at the interface of the chip and the tool rake face.

Question #3

You are tasked with designing one compact cylindrical riser for a sand mold used to cast a cube shaped aluminum part. Each side of the cube is 20 cm long. Assume that the riser sits directly on top of the mold cavity and is not open to the atmosphere. In order to obtain a compact design, you choose the diameter, ***d***, and height, ***h***, of the riser such that, for a given volume of the riser, the surface area of the riser across which heat transfer takes place is a *minimum*. In addition, you know that the smallest volume necessary for the riser needs to be at least three times the volumetric shrinkage of aluminum, which is known to be 7%.

(A) Determine the dimensions of the cylindrical riser that satisfy the stated requirements. Show your work and list all assumptions.

(B) Is the riser design obtained in (A) adequate to prevent the formation of shrinkage voids in the cast part? If not, what should be the volume of the riser in order to prevent such defects?