## Department of Chemical Engineering, IIT Kharagpur

## Fluid Mechanics (CH 20001) Mid-Semester Examination, 2015-16

## 2nd year B.Tech (H)/M.Tech (Dual) No. of Students 84, Time 2 Hrs., Full Marks 30

## Open Book Examination

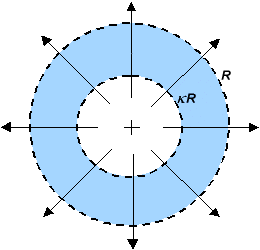
## Only the two textbooks by the following authors are allowed

## i) Fox & McDonald and ii) Bird Stewart & Lightfoot

## Any other book(s), photocopies of text books and class notes are not allowed

There may be handwritten notes on the pages of the book, but sharing of books is NOT allowed.

**Q1.** A viscous-shear pump is made from a stationary housing with a close fitting rotating drum (angular velocity, ω) inside. The clearance, ‘a’ is small compared to the diameter of the drum. Fluid is dragged around the annulus by viscous forces. Evaluate the performance characteristics of the shear pump (pressure differential produced, torque needed to turn the drum and input power (torque times angular velocity)). Find an expression for the efficiency of the pump which is defined as the ratio of the output to the input power. The output power can be approximated as QΔP, where Q and ΔP denote the volumetric flow rate and the pressure differential. Assume the depth normal to the diagram is b. **8 Marks**



**Q2.** An isothermal, incompressible fluid of density *ρ* flows radially outward owing to a pressure difference between two fixed porous, concentric spherical shells of radii *κR* and *R*. Note that the velocity is not zero at the solid surfaces. Assume negligible end effects and steady laminar flow in the region *κR* ≤ *r* ≤ *R*.

a) Simplify the equation of continuity to show that *r*2 *vr* = constant.

b) Simplify the equation of motion for a Newtonian fluid of viscosity *μ*.

c) Obtain the pressure profile *P*(*r*) in terms of *PR* and *vR*, the pressure and velocity at the sphere of radius *R* respectively. **2+2+3 =7 Marks**

**Q3.** A two-dimensional velocity field is given by . Determine the stream function, and the equation of the streamline that passes through the origin. Draw a rough sketch (without using a graph paper) of this streamline. **4 Marks**

**Q4.** Determine the vorticity field for the velocity vector **2 Marks**

**Q5.** A one dimensional flow is described by a velocity field where a and b are constants. Is the flow irrotational? For what combination of constants a and b will the rate of angular deformation be zero? **2 Marks**

**Q6.** A velocity field is given by where c is a constant. Determine the x and y components of the acceleration. At what point (points) in the flow field is the acceleration zero? **2 Marks**

**Q7.** A gas well contains hydrocarbon gases with an average molecular weight of 24. The gas may be assumed ideal with specific heat ratio of 1.3. The pressure and temperature at the top of the well are 16 atm and 20°C respectively. The gas is being produced at a slow rate so that the pressure drop due to flow can be neglected. Calculate the pressure at a depth of 3000 meters if (a) the entire well is held under adiabatic condition; (b) the entire well is held under isothermal condition; (c) the gas is incompressible. **2+2+1=5 Marks**