Lecture name/date	Topic 1	Topic 2	Topic 3	Topic 4	Flex	Notes	Trivia/Tidbits
8/22, lecture 1	ChEg curriculum	definition of transport phenomena	Many example scenarios!			Thermo tells us what can happen. Transport tells us how fast it will happen!	"Greates of all equations"
8_24, lecture 2	Most important fundamental principle in course: Momentum conservation	Blood flow from a fluid mechanics standpoint as a motivating example for the course. Also lungs, intestines, joints and brain barrier	O2 solubility in blood			Cooperative binding gives the "S" shaped curve and shows why hemoglobin can be saturated at partial pressures of ~90 Torr	Informs and abrogates "MONA"
8_29_17	A comparison of mass, momentum and heat transfer	Brain blood flow, Circle of Willis (redundancy)	Power to pump a fluid from 1st Law	Formulation of "shell balance" to conserve mass		We saw that the first law of thermodynamics won't be enough to explain fluid flow. We need conservation of momentum.	Should the "docs" call an engineer to do a calculation before they do surgery?
8_31_17	Derivation of differential mass balance	Some utility of mass balance	Formulation of differential momentum balance	Derivation of differential momentum equation		Note that Momentum is a vector quantity and so we get 3 equations if we consider only the scalar components of the vectors"Flow" terms are momentum/volume* volumetric flow across a face	Equation is always written such that left side is acceleration, right side is summation of forces.
9_5_17	Continued derivation of momentum equation: The forces	Body forces: Gravity; Surface forces: Pressure and shear stress, Surface forces require a stress tensor	Stress tensor is symmetric!	Still too many unknowns for the number of equations.	Need constitutive equations:	"Cauchy Momentum Equation" is the lingo for the complete, general differential momentum equations. Use of stress-strain relations for Newtonian Fluid Leads to Navier-Stokes equations	Stress -- strain equations for Newtonian Fluid are given in tables.

9_7_17	Extensive review of momentum/Navier-Stokes equations derivation	Solution of the first problems. Flow between parallel plates caused by plate moving	Discussion of boundary conditions: no slip, stress match.	Pressure driven flow between parallel plates	Gravity driven flow down a flat plate. No shear stress boundary condition at the liquid-gas interface.	Force on plate (Shear stresses), Average flow rate	Pressure decreases linearly in the flow direction
9_12_17	Recap of basic problems: Moving surface, gravity driven, pressure driven	Consideration of flow in a lung passage with liquid on wall and air in the middle of the tube.	Fluid statics, if no flow, just a relation between pressure and the change in the depth location of the fluid.	How to analyze a manometer	Gravity driven flow in a circular tube		
9_14_17	Review of manometer and gravity driven flow	Flow between rotating cylinders	Limit of this flow as curvature becomes small: Couette flow between parallel plates.	Transition to turbulent flow, definition of friction factor		Use friction factor-- Reynolds number plots to get pressure drop in pipe flow. Laminar and turbulent regions have very different behavior	Transition to turbulence occurs at about Re=2000-2500 for circular pipe flow. This is NOT a universal transtion criterion!
9_19_17	Transition to turbulence and turbulent flow overview	Constitutive relation for Bingham plastic and some observations	Falling film flow for Bingham plastic			Momentum transfer is much faster in turbulent flow because velocity fluctuations, "eddies" convect momentum. In laminar flow transport of momentum is only by diffusion	"momentum transfer" is in direction normal to flow
9_21_17	NonNewtonian fluid behavior	Constitutive equation for blood flow. Shear thinning and Newtonian at high shear rate	Blood flow, blood vessel branching				
9_26_17	Test 1 review	Set up picture	choose terms to include	integrate with BCs to get a velocity profile	Get stress and average velocity		

10_5_17	Some "Allometric" plots as a set-up for use of dimensional reasoning to interpret flow behavior	Concept of optimization as a trade-off between capital and operating costs.	Optimization principle gives "Murray's Law" (as does constant wall shear stress.)				
10_10_17	Non-circular cross section: What to do?	Exact solution for rectangular channel exists and we can use it	"Hydraulic diameter" can give good engineering results for non-circular cross section channels.	d_h = 4*cross section area/(perimeter that is in contact with flow)			
10_12_17	Flow of small particles as in dust carried in air	Re is small so rational simplification of N-S equations should be possible	Scaling and nondimensionalization suggests neglecting inertia is valid	Flow of small particles in your lungs; You have defenses against possible lung damage from small particles		Many examples of low Re flows are given. Chemical engineers "own" this branch of fluid mechanics.	Your defenses make aerosol drug delivery challenging!
10_24_17	Flow consequences of no inertia	Flow past a fixed sphere at low Reynolds number	Drag on the sphere, Stoke's settling velocity	Diffusivity of small particles.			
10_26_17	More discussion of low Re flows	Drag coeffient relation for all Reynolds numbers: Can get settling velocity for any Re with it	Suspension flows, viscosity increases with volume fraction of particles in suspension	Suspended drops or bubbles also increase viscosity	What if Re>>1? Scaling suggests that viscous terms are not important,but if so, we can't enforce no-slip condition.		
10_31_17	Derivation of of integral form of mass balance	Some use of mass balance: If flow area changes or branching occurs	Derivation of integrated form of momentum equation.	Discussion of how to use the momentum equations	Vector directions are critical, pressure terms are evaluated at "open" surfaces within the flow where we know the pressure	All of the tangential forces and unknown pressure forces within system are lumped into the "Force" term. This is usually what we solve for.	

11_2_17	Use of momentum equation for basic flow geometries.	Simplified form of integral balance that can be used for our problems	pipe flow, U bend, area change, elbow -- with angle,				
11_7_17 (test 2 review)	pipe flow w/ friction factor Re relation	Hydraulic diameter	Scaling that gave Re<<1 and Stoke's equations	Example low Re problems, rotating sphere, flow past sphere	Review of use of Momentum balance equation		
11_16_17	Motivation for one more equation	Use of first law to solve fluid flow problems: Derivation of Bernoulli equation ("cat z")	Use of Bernoulli equation for pipe system flows, what to use for "losses".				
11_21_17, Cardiology fluid mechanics	Discussion of how the heart pumps and how blood gets around your body	Some points about EKG and catheterization	Coronary arteries, stenosis and stents	Blood flow through heart valves. Relation between pressure drop , flow rate and valve stenosis	Stress on vessel walls and aneurysm		
11_28_17	High Re flows close to solid surfaces: inertia and viscous forces are both important	Need to incorporate this idea into scaling of N-S equations	Procedure with nondimensionalization of N-S equations by hypothesizing the need for 2 length scales. This works and gives a second(much weaker) velocity scale)	This also eliminates the flow direction 2nd derivative term and requires that the boundary layer thickness scales as 1/Sqrt(Re)	dp/dy ~=0 so that Bernoulli equation for inviscid flow will give the pressure on the boundary layer. This pressure does not change from the top to the bottom of the BL because dp/dy=0.		

11_30_17	More discussion of Boundary-Layer flows	Self-similarity arises, thus we attempt to simplify the PDE with a similarity variable.	Similarity occurs because there is no confining geometric length scale, but there is a specific relation between x and the top of the boundary layer	Use similarity variable to reduce PDE to ODE. Solve numerically			
12_5_17	Recap of boundary layer flows past plate and wedge	Developing flow in a pipe as a growing boundary layer.	Startup (transient) flow of a flat plate in an infinite domain. Again we expect self-similarity and again it works.				
12_7_17	How does your knee support such a large load with so low of a friction force	Hydrodynamic lubrication theory	"Slider" and "Squeeze film", Both can be analyzed with Reynolds equation	The reason that such a large load can be supported is that in both cases, a liquid is flowing within a very small gap. This causes a large pressure change within the joint.			