Forces breakdown

- hydrodynamucs solving for five variables over computational grid
- By setting grid points to 1, 1 dimensional thing to x
    - Finding value of five variables (but really three b/c velocity in y and z set to 0) at each grid point
- 3d moving in any direction
    - Theta = colatitude 0 to pi
    - Phi = longitude 0 to pi/2
- Five variables
    - Mass density (ex: g/cm^3)
        - Some things incompressible
        - Air is different
            - Air goes down as you go up
            - Density of air different where it's hot vs where it's cold
            - Very large changes in densities associated with shocks
            - Hydrodynamic shock = sudden discontinuous change in fluid variables
                - Density
                - Velocity
                - Pressure
    - Vx, vy, vz
    - Energy density
        - Both kinetic and thermal dynamic energy of random motion
        - Enthalpy = specific thermodynamic energy that appears
        - Energy/volume
- Five equations
    - Three equations = conservation of momentum
        - Either momentum equation and Euler equations
        - In three dimensions
    - Two other
        - Conservation of mass
        - Conservation of energy
- Conservation of mass, momentum, and energy
- Momentum conservation
    - F = ma for a fluid
    - Ma part = multiple particles —> mass per volume of a fluid*acceleration
    - F = all the forces
        - d^2y/dt^2 = a
        - Have to know forces in system

- Pressure forces
    - High pressure on one side, low pressure on other side, flow from high to low
  - Gradient of scalar quantity
    - Gradient of pressure(*-1)
    - DP/dz = vertical component
    - ALWAYS SAY PRESSURE GRADIENT FORCE
  - Winds don't point towards high to low because influence of Coriolis force
    - Balance of horizontal pressure forces against Coriolis
    - Geostrophic balance
- Forces:
  - Pressure forces
    - Weather driven by horizontal
    - Vertical pressure gradient pushing out
    - Stable equilibrium on earth
      - If gravity went away, then the atmosphere would explode
      - Shocktube = sudden change in pressure/imbalance —> moves to right/moving away from discontinuity
        - Higher density on left, lower on right
        - When everything same = no more forces
    - Force per volume
  - Gravity forces per volume
    - Mass density G*newtons constant/rad^2
- Conservation laws for mass and energy
  - Mass conservation
    - Mass doesn't appear or disappear
    - box: how to change total mass in the box?
      - Moving things in and out of a boundary
  - Energy conservation
    - Internal energy
    - Transformed into different forms but total is conserved
    - Three different type
      - Grav potential
      - Bulk motion of entire fluid
      - Internal fluid
        - Ind. move faster when hot and vice versa
    - Adiabatic motion
      - As fluid moving around
        - No heating and cooling = non adiabatic
        - Entropy is constant
        - Fluid with volume change and expand —> cools

      - Impose heating and cooling by prescription of heating on day, cooling at night
        - Newtonian cooling = prescribe temperature that fluid should have (equilibrium temp)
        - Write func = less than eq, heating and vice versa
- Having simulations in three dimensions with spherical
  - Lower boundary with not much happening
  - Region of strong day nigh heating
  - Upper layer
  - Vertical gravity
  - Horizontal pressure gradients driving winds
  - Understand when you have winds, do they cause density variations that star can hold on to
- Switch from cartesian to spherical coordinates
  - Blast wave example?
    - 3d version of shock tube
    - Small r = huge overpressure in comparison to larger r
    - Cause shock —> fluid move outward
  - Try running case in spherical coordinates
  - See if you can get plots to work
  - Density, radial velocity, internal energy in r
- coordinates:
  - X1 = r
  - X2 = theta
  - X3 = phi
  - X2 and x3 = 1 for this blast wave
- Run blast wave and read one of the time slots
  - Then plot density vs radius