MEGN261 TOC

MEGN261 - 2025-01-08

#notes #meche #megn261

Housekeeping Things

- You can go to... whatever thermo section you want. Have fun.
  - There's six sections, 8/9/10/11/12/2
  - Office hours also exist
- Grade things
  - 60% of the course is exams! Yipeee!
  - 20% is shenanigans with EES
  - Grades are rounded up by 0.5%, which is neat
    - Also no plus/minus
  - This time is going to be a solar panel array thingy
- "A lot of you have bad problem solving skills"
  - Brutal.
- Completely unrelated Mines fun fact, we're the third largest mechanical engineering department
  - Also, eat shit ASU
- PCJ is too important to deal with us
  - 2.2014 is the start of the correct answer to some homework question, if the numbers aren't randomized
- Local sig fig hater
  - "Put a safety factor on that" goes CRAZY as an approach to answers
  -

MEGN261 - 2025-01-10

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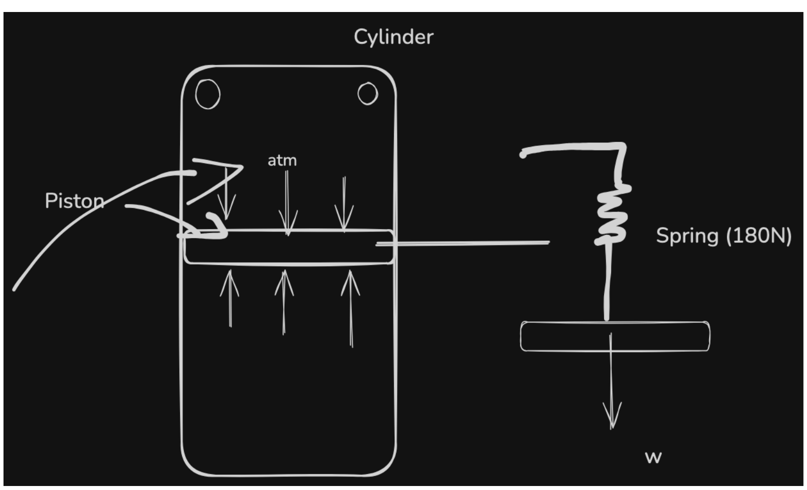
Fun with units

- Thermo (the class) just uses SI now
  - They used to use imperial as well
    - If you work for the government (which,frankly, we probably are), you're going to have to use both
  - The United States is inconsistent as shit
  - Which units *do* we use and write things as?
    - Volume - m^3 - $\forall$ (it's really v with a bar, but I'm still figuring out typing that)
    - mass - kg - m
      - $\dot{m}$ is rate/time/sec. It's $\frac{\text{kg}}{\text{sec}}$, which is for mass transfer
    - If you slap a dot on top, that is (unit) of flow rate per second, so like $\dot{\forall}$ is the flow rate of some fluid in m^3/sec
      - Normal V is velocity, but it does come up, sometimes. probably.
    - When you divide by mass $\frac{}{\text{mass}}$, we call that "specific"
      - ie, $\frac{\forall}{m}$ is specific volume, m^3/kg
      - Anything that's specific is written lowercase - the aforementioned specific volume is v
    - There are shenanigans with phase that I didn't write down
    - Pressure is Pascals, we use kPa
      - Bar and PSI also exist, as do PSI, especially PSI in lots of other things, but we use kPa, soooooooo, oh well
      - $P_{\text{absolute}} = P_{\text{atm}} + P_{\text{gauge}}$
        - There's something in the reading about a vacuum
    - Force is pressure times area
      - SI is newtons, here we use kN



- We're calling up positive, because, y'know what, feel like it
  - That one pointing up is up, down is down, yadayada, you can do some shenanigans with units. Pay attention to it

- Power is represented by no less than three different symbols, because fuck you. $\dot{W}$, W, and w.
  - $\dot{W} = \frac{kJ}{s} - kW$
  - W is kJ
  - w is $\frac{kJ}{kg}$
  - That's rate, no rate, and specific. It does, annoyingly, follow the conventions and make reasonable sense.

I'm doing a whole new heading here.

Someone just said the phrase "specific mass." I feel this needs calling out.

ok back to main work

$$\frac{kJ}{kg} * \frac{kg}{s} \rightarrow \frac{kJ}{sec}$$

- Oh hey, $\frac{kg}{s}$ is $\dot{m}$. Ain't that neat.
- Back to specific volume, $v = \frac{m^3}{kg}$
  - Ain't it silly, but density is $\rho = \frac{kg}{m^3}$
  - Reportedly, the easiest equation we have is $v = \frac{\forall}{\text{mass}}$
- toDo: put this in a table

Let's say we're on the exam

- Other than, as they say, going through it, what can you do?
  - Do unit shenanigans.
- A 1L tank has 1kg of water, what is the specific volume? (in $\frac{m^3}{kg}$)
  - $\frac{1}{1000}$, because liters are some shenanigans
  -

MEGN261 - 2025-01-13

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housekeeping

- by homework three, there is 1. no multiple choice 2. it fucking sucks
- also switching to wednesday to-dos, career day that moves to thursday, then back to wednesday

further adventures in vocab

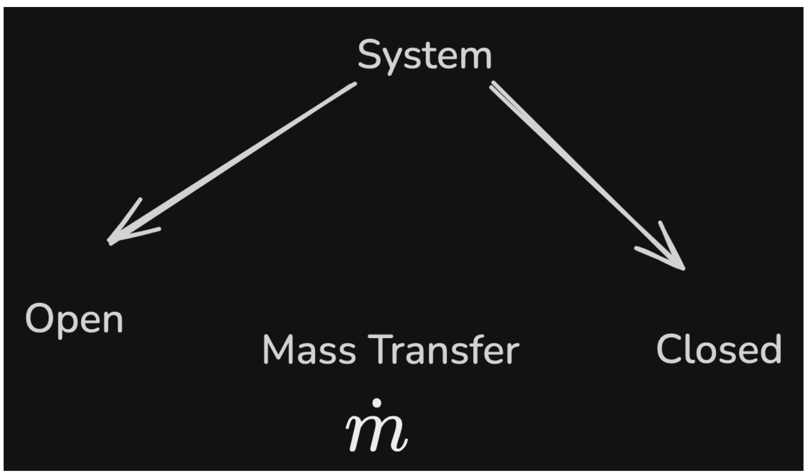
Quick recap

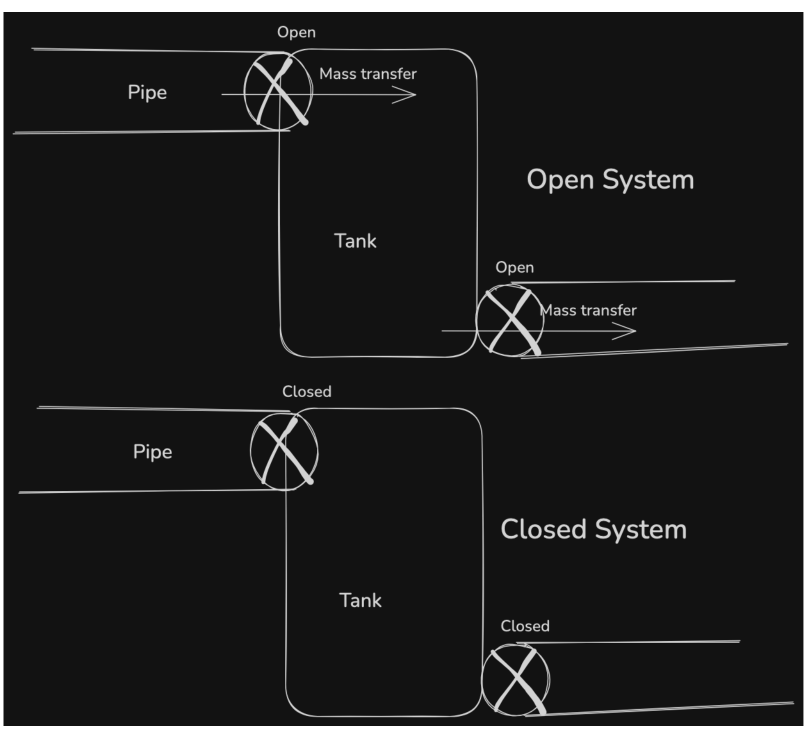
- $\dot{W}$ is power, kw, $\frac{kJ}{s}$
- W - kJ
- w is specific $\frac{kJ}{kg}$
- m - mass, kg
- $\dot{m}$, mass transfer, kg/s
- $\dot{\forall}$ volumetric flow rate
- $\forall$, volume
- V, velocity
- v, specific volume

Dealing with Systems

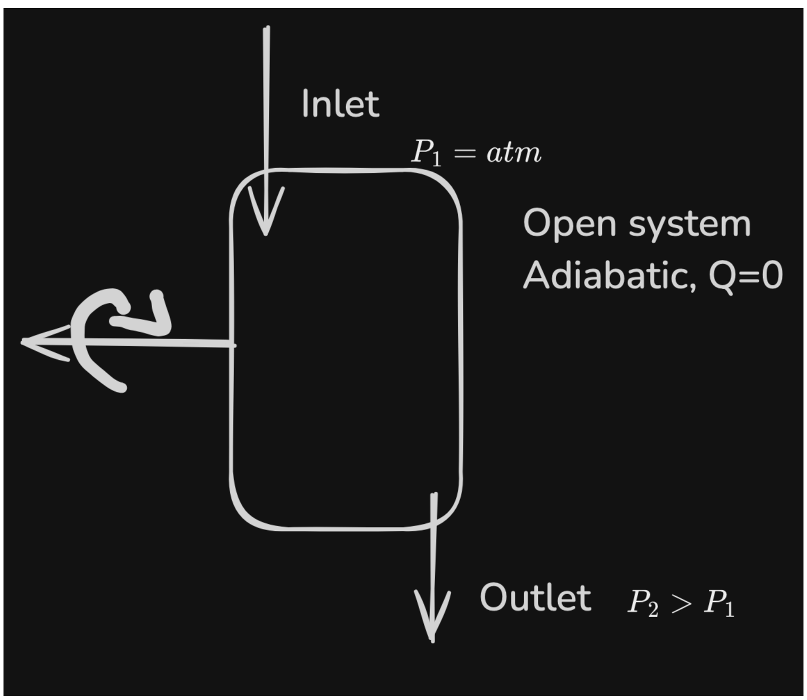
- We have some system, with some defined system boundary
- Energy
  - Work
    - Different forms of work (holy moly the handwriting on that one)
  - Heat Transfer, Q
    - Radiation, convection, conduction. Good news: here in thermo we only care about heat transfer across the system boundary.
      - Is heat leaving? Is it going in? We only care if it goes across the boundary
        - Otherwise, that's what we in the business call a violation of the first law of thermodynamics. You get a citation for creating (or destroying) energy.
        - Also, generally, cooling down (losing heat from the system) is negative, and adding energy in is positive. This means literally nothing except for the fact we feel like it should
      - This also applies for work

                - Also, fuck you. Work is backwards. It's just the opposite of heat transfer, but regardless, fuck you. Work done to the system is negative, work out, what's done by the system, is positive.
    - Example: Compressor in refrigerator
        - The compressor in there is work done to the system in moving refrigerant around
    - Generally, we talk about work done *by* the system, like the many, many kinds of turbines
- All kinds of other shit can also happy, but we don't care!
    - Chemical reactions are, like, objectively energy. Not our problem. We do work and heat transfer.
- If we say the system is "adiabatic", there's no heat transfer
    - That literally only comes up as a term in textbook, otherwise it's insulated
- Drod systems flowchart





- Heat could be transferring through either of these! Energy has absolutely nothing to do with the mass, which is something I somewhat struggled to get through my head.
- There is a pump *somewhere*, but there's quite noticeably not any work happening in the system.
- We've talked about conservation of energy, what can we talk about?
  - In the closed system, we can absolutely talk about heat transfer
    - work, $w = 0$
    - $Q = \ ?$
    - If it's both closed and adiabatic, go home. It's dumb. Nothing happens.
  - In the open system, it'd be so neat if it was always $\dot{m}_{inlet} = \dot{m}_{outlet}$
    - That does not always happen. Maybe there are shenanigans at place with some process in the middle, tank is leaky, shitty measurement, outdated information, blah blah
      - $10.01 = 10.10$. I love math
- Shenanigans with an air compressor



- You could solve for a couple things
  - $\dot{m}_1 = \dot{m}_2$
    - I mean, probably not, because leaks are a pain in the neck, but you get it
  - More likely that you need to solve for power and how big this needs to be
  - If not adiabatic, could also be given heat transfer (ie, $Q = 100kW$)
- The only other closed system other than a tank that really comes up is piston cylinders
  - There was one on the homework!
- "Computational fluid dynamics" sounds objectively horrifying

- Flow of the class is Vocab $\rightarrow$ Equation $\rightarrow$ Exam
  - We really just kind of have conservation of energy/mass, and then getting horribly, horribly confused somewhere along the way.
-

MEGN261 - 2025-01-15

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- We've only really been talking about the left hand side of conservation of energy, $\dot{Q}$ and $\dot{w}$

If we write it aaaaalll out, we get

$$\dot{Q} - \dot{w} = \dot{m}(? + \text{KE} + \text{PE})$$

- All of the bits in the parenthesis need to be specific - ie, $\frac{kJ}{kg}$
  - When ya see kinetic energy, think "velocity"
  - Velocity started as m/s, kinetic energy, as a vibe, is $\frac{V^2}{2}$
  - notably, that gives units of $\frac{m^2}{s^2}$, which is, how you say, not kj/kg
  - If you multiply by 1000 in the denominator, that turns it into $\frac{kj}{kg}$
  - So the book will just have the equation $\frac{V^2}{2*1000}$

$$\text{Kinetic energy} = \frac{V^2}{2000}$$

- Quick pipe aside

$$\dot{m} = \rho AV, \text{ or } \dot{m} = \frac{AV}{v}$$

  - Said pipe has an inlet and an outlet, which we call "states" here in thermo
    - We need two properties to fix a state
      - If we have pressure and temperature, we can determine phase
  - Writing ΔKE across this pipe would get you $\frac{V_2^2 - V_1^2}{2*1000}$

If you aren't given kinetic energy or velocity or anything - don't worry about it! Not your problem!

- Mechanical energy uses a lowercase e
  - Talking about $\text{flow energy} + \text{kinetic energy} + \text{potential energy}$
    - We don't really use flow energy in here, which is pressure/density, or $\frac{P}{\rho}$

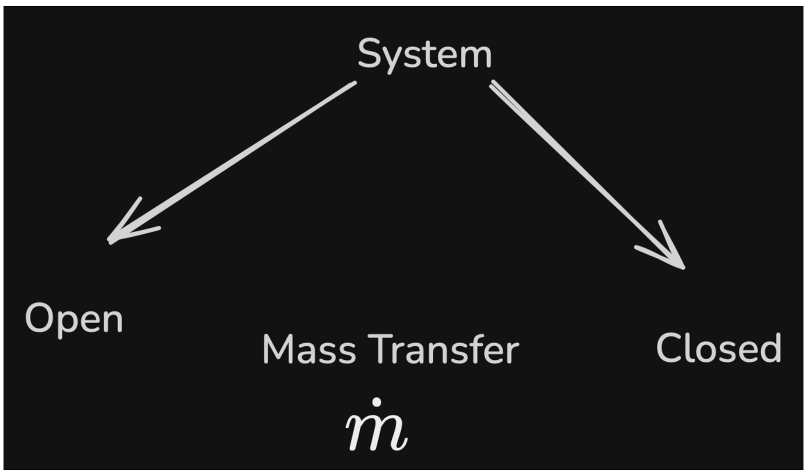
- Alternatively, Pv (pressure times specific volume) is also flow energy

Potential Energy

- Still needs to be kJ/kg, just for notes
- When vertical distance changes (Δz, in conventional nomenclature)
  - This math (in SI) is just $\Delta z * g$, which, again, units are wrong, buuuut, you just divide by 1000 again because metric was made by actually reasonable people and it all works out.

$$\text{Potential energy } = \frac{\Delta z * g}{1000}$$

- Don't have em, don't need em (unless you're using a computer, because at that point it's free, but, regardless)



- There are two different vibes: if we're open or if we're closed
  - When we're open:

$$\dot{Q} - \dot{w} = \dot{m}(\Delta h + \Delta ke + \Delta pe)$$

    - That Δh is enthalpy! Enthalpy goes with open. Use the right equation. You will probably get very familiar.
  - Meanwhile, when we're closed, we get

$$\dot{Q} - \dot{w} = \dot{m}(\Delta u + \Delta ke + \Delta pe)$$

    - u is "internal energy," which apparently never comes up past exam 1
      - water stuck up in some tank for instance is stored or internal energy, and if you pop a valve and release it, off it goes (and it no longer becomes a closed system)

    - Also, am i tripping or is the right side always going to be zero when we're closed? like? am I missing something? why does what's inside matter at all?
      - well like $\dot{m}$ is going to be zero because if it's closed there's no mass transfer
  - Fun little note, enthalpy isn't, like, real
    - Strictly speaking, $h = u + Pv$
      - Which, in not strange characters, is internal energy + flow energy

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Fun with the power of a steam turbine

- You have some steam turbine with state one and state two (in/out at some speed(s))
  - got nothin on kinetic, got nothin on potential, we're given $-\dot{w} = \dot{m}(\Delta h)$
- Homework problem where we get given $\dot{Q} - \dot{w} = \dot{m}(\Delta u)$

you can't just sit and daydream about problems for six hours

WRONG! watch me!

- can get mass in a tank by going $\frac{\forall}{v}$ (rigid tank over specific volume)

MEGN261 - 2025-01-17

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types of work

1. Shaft
   1. Pump, compressor, steam turbine, gas turbine

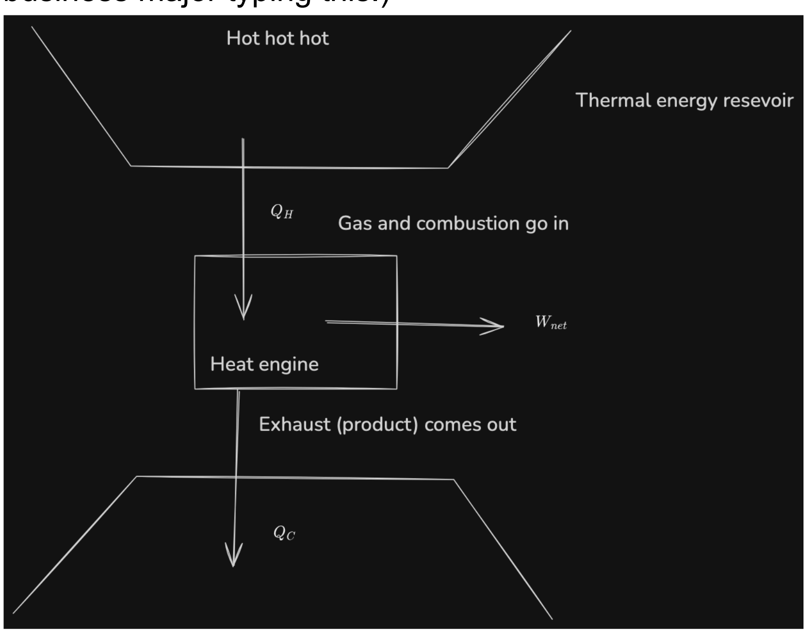
   

- Just leaving this in here as a record for handwriting

2. Boundary Work
    1. Piston cylinder is the literal only way that this comes up in Thermo 1. $W = PdV$, pressure times change in volume
        - . Which is literally just $\forall_2 - \forall_1$
        - And we just care about the volume *contained by the piston*, not above, not below, what's inside the darn thing
            - An expansion is increasing in volume, compression is decreasing
3. Electrical Work (RCIII type shit)
    - $w_{electrical} = V * I$
    - After exam 1 this never comes up again, merry christmas. (we're not going to talk about EEGN281.)

2nd Law Statements

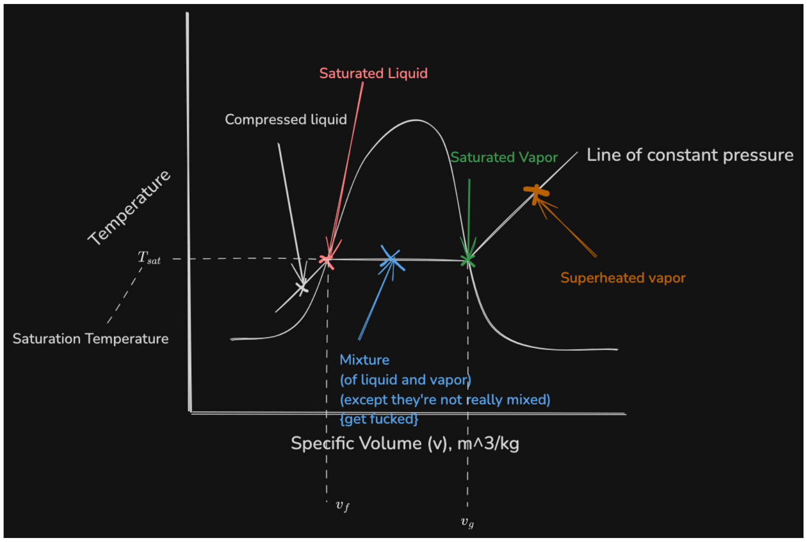
- There's a good deal of things that don't technically violate the first law, but we have the second law to be a fucking 🤓 and yell at us about it
- First up, efficiency
  - η_{th} is thermal efficiency
  - $0 - 1 * 100$
  - Equation for $\eta_{th} = \frac{w_{net}}{Q_{in}}$
  - w_{net} is profit - cost (econ major type equation. generally the profit is bigger. i feel like a business major typing this.)



- η_{th} comes up the whole damn semester

chapter 3: the fun part

- The whole gimmick here is phase change



- The mixture is also referred to as "quality" - how much vapor is in the steam, which is relevant for steam blades and such
  - Quality uses x, which is ≤ 0.8
- As you go more right more vapor, more left more liquid (left is liquid! at least that works out nicely)
- We use a particular pump called a "radial flow pump," which *requires* an input of saturated liquid
  - We add pressure to push it to a higher elevation, which leads to a compressed liquid coming out
  -
- We say we have some steam turbine, we could run it at 0.8 quality, but why bother if we don't want liquid on the blades? So just push it to superheated vapor
  - As the steam expands through the turbine, it drops in phase down to mixture
- Anything that has to do with saturated liquid has the subscript $_f$, and anything with saturated vapor has to deal with $_g$
- Vapor content (quality, x) is $\frac{m_{vapor}}{m_{liquid}+m_{vapor}}$ (you could also do water content but like irrel)
- Given any of the quantities we care about, $x = \frac{v-v_f}{v_g-v_f} = 0 < x < 1$
  - you don't need v, could be h_f or u_g or what have you
- Dealing with some examples
  - If temperature is greater than T_{sat}, we're a superheated vapor
  - If temp is less than T_{sat}, we're a compressed liquid
  - If it's the same, you quite unfortunately have three possible phases. Go fish.
- We're a furniture store, we've got some tables
  1. You start on the saturated mixture table

2. If things go poorly, you go to over to either the superheated vapor table or the compressed liquid table

- We have tables for Water and R-134_a, which is a refrigerant that is now banned for consumer use (womp womp)

P_{kPa}	$T_{T_{sat}}$	v_f	v_g	u_f	u_g	h_f	h_g	entropy jumpscare
blah								
blah								
lah								
200	310							

- Say you get given a pressure of 200, and a temperature of 340.
  - You look at the table, go damn, 310 is not 340, so you move on to the superheated table in this case
  - Say you get given a temperature of 280, you leave to the compressed table
- I do not intend to draw phase diagrams when bored, but, I appreciate the sentiment.

MEGN261 - 2025-01-24

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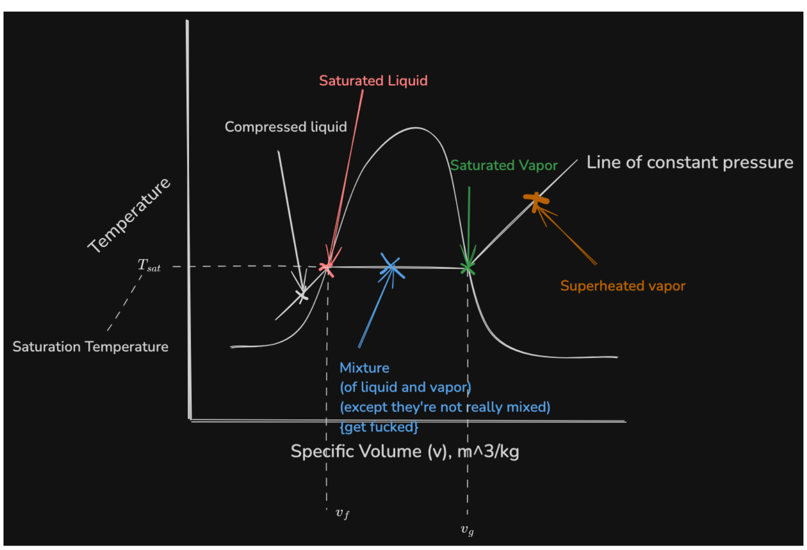
more fun with the big dome diagram



- That one, for the record
- If you had a graph with pressure as your dome, a constant temperature line would be the opposite, start going down, go across, and come down

now to go to the tables

Table A-5: Saturated water - Pressure table

- One of the table entries is evaporation

$$x = \frac{v - v_f}{v_s - v_f} = \frac{10 - 0.00101}{14.67 - 0.001010} = 0.682$$

- That's more vapor-y, just for records sake
- If you were for some reason going the other way
- If you get fucked and something is in between temperature values, google "Linear Interpolation calculator" and go have fun with that
    - We learn EES after exam 1 which can actually do that for you
- Chapter 4 is closed systems
    - Now hang on, we've talked about those
- Chapter 5 is open systems
    - Now hang on, we've talked about those
- You're going to have to get good at lookups because that's a very very large part of the exam

We only deal with ideal gasses in here

- Which behave predictably
  - Air, propane, argon (make sure it doesn't expire in three days), a whole list

$$P\forall = nRT$$

- Is quite, quirky, has moles, don't give a fuck.
- Publishers came up with the "perfect" gas law

$$m = \frac{P\forall}{RT}$$

- the R in this equation is species specific
  - Some relevant unit bits - your temperature needs to be in Kelvin, pressure in kPA, volume in m^3, R has some funky units to cancel the rest of that out to get kg out
  - for instance, 0.287 for "air"

$$\frac{P_1\forall_1}{T_1} = \frac{P_2\forall_2}{T_2}$$

- That's if we're told mass is constant and we're sticking with the same gas, so, lots of fun relationships there where simple relationships can make the algebra like actually possible
- Be incredibly, remarkably careful that you don't do a lookup when you're really dealing with a gas, or vice versa
-

MEGN261 - 2025-01-27

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drod career day reccomendations

- Set your resume up as
  - Header
    - Have LinkedIn
  - Education
  - Projects
  - Work experience
- Ideally, lock up two internships so you can have job offers going into senior year
  - bare minimum one. you're deadass throwing with zero.
  - Once you willy wonka your golden ticket into one internship, it's really easy to get a second one
    - Shoot the good industries instead of fighting for your life in like biomed engineering or aero
  - Feel free to do a little white lie like toss EES on, since you'll be fluent by the time it matters for them
  - Lob activities/hobbies on the end if you have spare space
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MEGN261 - 2025-01-31

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Housekeeping Things

- Chapter 4 and 5 readings are both half size, but the homework is combined
- Table A-2 water uses 4.18 regardless of whatever it is

(ideal gasses)

Constant Specific Heats

- Amount of heat transfer required to raise temperature of mass 1 degree C
- Ways to calculate U and H
  - Once upon a time, we used air tables and you would look it up as a function of temperature
  - Nowadays we use EES to make a function call (it's 2025. get good)
    - You can also use like matlab, python, whatever the fuck else.
  - Can also use a function of temperature on a table
    - Since we're going by hand, using constant specific heats is the way to go
- Closed and open systems
  - If it's closed, $\rightarrow$ internal energy U
  - If it's open, $\rightarrow$ enthalpy H
  - If we're looking at constant specific heats, for closed, $\frac{dU}{dT} = c_v$
    - for open, $\frac{dH}{dT} = c_p$
  - c_v is constant volume, c_p is constant pressure
  - $dU = c_v dT$
    - Change in internal energy = $0.787 \frac{kj}{kg*K}$ (for air) and $(T_2 - T_1$(K)
  - $dH = c_p \Delta t$
    - Change in enthalpy = 1.005$(T_2 - T_1)$
- That works wonderfully for ideal gasses, now for

Solids! (I hope they work)

- $c_p = c_v = c$
  - It's a solid. So it's a constant pressure, a constant volume, just some constant c based on the metal
  - So then $dU = c\Delta t$
    - There's the one question on the homework about like an iron block. Put your temps in kelvin and deal with it like this.

Liquids! (I don't have a good pun)

- $c_v = c_p = c$ for liquids as well

Specific Heat Ratio

$$k = \frac{c_p}{c_v}$$

- We're going to eventually develop "isentropic relationships" which are raised to the power of k. That's a problem for like two weeks from now.

Methodology or something

1. Fluid?
    - If you work a problem in the wrong fluid you are just, quite simply, fucked.
    - R-134a and water are done with lookups
    - Air we use constant specific heats and the ideal gas equation with
2. Closed or open?
    - Is there mass transfer? is $\dot{m}$ real?
        - Piston cylinders and tanks are closed, everything else is open.
    1. Closed (kw)
        1. $\dot{Q} - \dot{W} = \dot{m}$ all goes to zero. Every time when you're closed. Every single time.
        2. $Q - W = m(\Delta u + \Delta ke + \Delta pe)$
            1. If you're specific, you drop to $q - w = \Delta u + \Delta ke + \Delta pe$
    2. Open
        1. $\dot{Q} - \dot{W} = \dot{m}(\Delta h + \Delta ke + \Delta pe)$
3. Conservation of Mass

$$\dot{m} = \rho A V$$

   - This is that one turbine problem.
4. Ideal gas equation
   - $m = \frac{P\forall}{RT}$

$$\frac{P_1 V_1}{\cancel{R} T_1} = \frac{P_2 V_2}{\cancel{R} T_2}$$

- First thing you do on a water problem is you figure out phase! First thing you do!
  - When you figure out you have a mixture, you figure out quality

$$x = \frac{v - v_f}{v_g - v_f}$$

- Y'know, written somewhere already, but never hurts
- Once you have yourself x, you can solve for h and u
-

MEGN261 - 2025-02-03

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Assorted real life notes and other miscellaneous shenanigans

- For pumps and compressors, $P_2 > P$, so you can check your work

"What a heat exchanger does is exchange heat"

- Honestly, there's a whole long explanation here about how when you have a turbine, you feed mixture into a heat exchanger which gets cooled and then thrown back into a pump, but that's frankly a problem for like months from now so I didn't bother to write stuff down.

MEGN261 - 2025-02-05

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Heat Exchanger Assumptions

- Constant Pressure
  - Q_{in} or $Q_{??}$
- R-134a is to be cooled by water in a condenser. The R-134a enters the condenser with a mass flow rate of 4 kg/min @ 1MPa + 70°C + leaves at 35°C . The cooling H2O enters @ 300kPA + 15°C and leaves at 25C. Neglect pressure drops (which means

constant pressure)

$$\frac{\partial \mathfrak{y}}{\partial \mathfrak{x}}$$

- Find m_w (kg/min)
- The hate transfer rate from the R-134a to the H2O (kJ/min)

Let's get a-crackin

1. **Open** or closed?
    1. Which means we're using h
2. What fluid? R-134a and H2O
3. Write your states

State 1	State 2	State 3	State 4
H2O	H2O	R-134a	R-134a
300 kPa	300 kPa	1000 kPa	1000 kPa
15C	25C	70C	35C
h_1=??	h_2=??	h_3=??	h_4=?

$$\sum dotQ - \sum \dot{w} = \sum \dot{m}(\Delta h + \Delta ke + \Delta pe)$$

$$\sum E_{in} = \sum E_{out}$$

$$\dot{m}_1 = \dot{m}_2 = \dot{m}_w$$

$$\dot{m}_3 = \dot{m}_4 = \dot{m}_r$$

$$\dot{m}_w h_1 + \dot{m}_r h_3 = \dot{m}_w h_2 + m_r h_4$$

- Hey, in case we've gotten lost, we're looking for $\dot{m}_w$

$$m_w(h_1 - h_2) = m_r(h_4 - h_3)$$

$$m_w = m_r * \frac{(h_4 - h_3)}{(h_1 - h_2)}$$

- Oh hey we did it. Yippee.
- Now for that heat transfer rate

$$\dot{Q}_w - \cancel{\dot{w}} = \dot{m}(\Delta h + \cancel{\Delta ke} + \cancel{\Delta pe})$$

$$\dot{Q} = \dot{m}\Delta h$$

$$\dot{Q} = \dot{m}(h_2 - h_1)$$

Systems

- Tank is closed.
- Piston cylinder is closed.
  - PdV for work
- c_v is closed
  - $\Delta v = c_v \Delta t$
- Compressor is open.
- Pump is open.
- Steam turbine is open.
  - Or, y'know, any other turbine
- Heat exchanger
  - Bit of a shocker if you have any heat exchange anywhere but a heat exchanger
  - So we're *probably* solving for work
  - $c_p \Delta t = \Delta h$

$$\dot{m} = eAV$$

$$\dot{m} = \frac{AV}{v}$$

$$\dot{m} = \frac{(\text{Area})(\text{Velocity})}{v}$$

$$m = \frac{P\forall}{Rt}$$

MEGN261 - 2025-02-07

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Exam 1 Review and Housekeeping Things

- **REMEMBER YOUR CALCULATOR DUMBASS**
- Constants are given, if your lookup isn't exact you fucked up.
- Exam is Chapters 1-5, so anything about COP is chapter 6 and not the problem
- Also homeworks 1-4

    - Homework solutions are getting updated and such
- Short answer, quick lookup type shit
- There are only four problems!
    - That's fucking horrifying, for the record.
- Something something fear is the mind killer, just lock in
- Air is special and not a lookup, don't do air for a lookup problem, don't do lookups for an air problem
- Do your states!
- If someone walks out of the room, closes the door, and screams, I *will* laugh
- Fear might be the mind killer, but time is the grade killer
- I would bet money that homework 3 is number 3

MEGN261 - 2025-02-12

#notes #meche #megn261

- EES is not case sensitive, variable names can be up to 30 characters
    - Semicolons work to split lines
- Comments are with `{}` or `""`
    - `{}` comments don't show in the formatted equations window
- Use a parametric table to vary one or more variables
    - So *this* is the equivalent of how loops work
    - Type your equation as normal, make a table to vary it, bob is uncle.
- EES looks ugly as sin because all of the resources went into speeeeeed.
- The function `Convert(unit1,unit2)` spits out a conversion factor that you can multiply by
- You need to use `ConvertTemp(unit1,unit2,temp)`
- You can declare units with numbers, but not types.
- The variable info window is where you do a lot of things, the check units button does like, a bit of a vibe check.
- Can do arrays and loops but we unfortunately skipped over them
- Property plots (making phase diagrams) are in fact totally possible

MEGN261 - 2025-02-24

#notes #meche #megn261

Chapter 6 (I missed the first day of, yay for recap)

- Real Equations
  - Thermal efficiency = $\eta_{th} = \frac{wnet}{qin=qh}$
  - $COP_R = \frac{Q_C=Q_R}{W_{net}}$
  - $COP_{HP} = \frac{Q_H}{W_{net}}$
- Ideal (Carnot)
  - Thermal efficiency for Carnot is $= \eta_{th} = 1 - \frac{T_L}{T_H}$
  - $COP_R = \frac{T_L}{T_H - T_L}$
  - $COP_{HP} = \frac{T_H}{T_H - T_L}$
- Any time you see "max" or "highest" you're dealing with the theoretical best, which is Carnot
- We irreversible and reversible
  - Reversible can be written as Carnot
  - Irreversible is actual, you could go buy a heat pump and it'd check out more
    - This means you have losses, you can't get it back
    - Thermo textbooks love to call this "thermal friction"
- We carry η_{th} forward as we deal with engines and power plants, we lowkey do not give a shit about the rest.

Heat Pump Problem

- $W_{comp} = 68\frac{kj}{kg}$, House is 18C or 291K, outside temp is -16C or 257K
- R-134a enters the condenser in the house @ 1000kPA and 50°C and it leaves at 1000kPA and is a saturated liquid
- So doing our states of the heat exchanger
  - $P_1 = 1000$kPA
  - $T_2 = 50^{\circ}$
- We want the highest COP_{HP}, which means we want the Carnot equation 6

$$\frac{291}{291 - 257} = 8.6$$

- At what rate is heat provided to the house from the condenser (kj(kg))
  - Those are just lookups. Do your lookups for h, and bob's your uncle. Apparently, 175 kj/kg is the final answer

- What is the actual COP of the heat system?
  - It's a heat pump. It says actual. Use equation 3, the real heat pump equation.

$$COP_{HP} = \frac{q_H}{W_{net}} = \frac{175}{68} = 2.57$$

- This is less than COP_{HP} from the Carnot bit, so yeah, this checks out.

Entropy Time (Chapter 7/8)

- Entropy is S, $\frac{kj}{K}$, s is $\frac{kj}{kgK}$
- Lookups are the exact god damn same.
- Entropy depends a good bit on scale
  - ME cares about the macro scale, physics care more about the micro scale, and have all kinds of actually interesting things (that we don't really care about)
  - We're engineers. We need numbers. Things need to make sense.
    - We gotta quantify a loss
- When we have some η_{th} value, that's great for knowing that things are kinda bad, but we don't know the specifics of the irreversibilities, which is what the entropy is for
- Now, if you're a Youtuber, you're going to say that entropy is always increasing in the universe, but a more boring but yet true topic is that it's also associated with a heat transfer @ some boundary T
  - You can also say entropy is "a measure of the disorder of the universe" which is awesome! Neat for physics kids! Does uh, not really help us as engineers.
- We got three big tricks! And that's it!
  - Conservation of Matter.
  - Conservation of Energy.
  - And the final shmuck, Entropy. Who doesn't fit and makes this less symmetrical

$$\frac{ds}{dt} = \dot{m}\Delta s + \underbrace{\frac{\dot{Q}}{T_b}}_{\text{Boring engineer}} + \overbrace{Sgen_{universe}}^{\text{Youtube term}}$$

- $\frac{ds}{dt}$ is going to be steady state, constant, which is neat
  - $\Delta s = (s_2 - s_1)$, which, that term is entropy associated with mass transfer (it's from lookups)
    - If your system is closed that term poofs
  - T_b is your boundary temperature, if you're adiabatic, it poofs away.

- The "Universe" is your control volume, which tends to be like, the turbine itself when you're dealing with a turbine.
  - T_b is outside the universe
- $S\dot{gen} > 0$, but in an ideal or reversible system, $S\dot{gen} = 0$.
  - It however, DEFINITELY VERY MUCH *CANNOT* be less than zero.
    - No dice. Go home.
  - S_{gen} of zero is isentropic.
-

MEGN261 - 2025-02-26

#notes #meche #megn261

- Remember to do the thermo homework, dumbass.

The Big Topics from Chapter 7/8

- COE, COM, and Entropy of H2O/R-134a, and that's really it.

Real Notes

$$\frac{ds}{dt} = \overbrace{\dot{m}\Delta s}^{\text{Mass transfer}} + \underbrace{\frac{\dot{Q}}{T_b}}_{\text{Heat transfer}} + \overbrace{S_{gen}^{\cdot}}^{\text{Disordered Universe}}$$

- To cover some of the general statements into what's actually real
- Entropy is always increasing in the universe
  - This is $S_{gen}^{\cdot}$
- Entropy is always increasing (which means it cannot decrease)
  - if $S_{gen}^{\cdot} = 0$, that's the ideal case
  - If $S_{gen}^{\cdot} < 0$, you did something wrong and are drunk. Go home.
- $\frac{ds}{dt}$ is zero since we're steady state and there's no change over time.
- If we're closed then $\dot{m}\Delta s$ is zero since no $\dot{m}$.
- If we're adiabatic $\frac{\dot{Q}}{T_b}$ is zero since adiabatic.

Now we need to deal with ideal gas

- This really should've been in chapter 3, but, w/e
- We're still using constant specific heats because we're doing this shit by hand.
    - Do not EES ideal gas problems because they're based on constant specific heats
        - At a job you will absolutely be using EES
- We get two equations, based on cp and cv respectively
    - Where do they come from, exactly?
    - Gibbs (free energy) or Tds
- Closed - COE

$$\underbrace{Q}_{Tds} - \underbrace{w}_{Pdv} = \underbrace{\Delta u}_{Cv\,dT}$$

$$TdS - Pd\forall = Cv\,dT$$

$$dS - \frac{Pd\forall}{T} = \frac{Cv\,dT}{T}$$

$$dS = \frac{Pd\forall}{T} + \frac{CvdT}{T}$$

$$ds = \frac{Pdv}{T} - \frac{CvdT}{T}$$

$$\boxed{\underbrace{s_2 - s_1 = C_v \ln\frac{T_2}{T_1} + R\ln\frac{v_2}{v_1}}_{\text{Closed system equation}}}$$

- The fuck did that R come from?
    - Blatant fucking wizardry, in short.
        - $c_p = c_v + R$, yadayadayada, the math works. I swear.
- Equation (7-33) in the book, for record's sake
- Now for open systems, which we're going to go into even less detail on, somehow.

$$Tds = dh - vdP$$

- We tossed out boundary work somewhere along the way.

$$Tds = c_p dT - v(dP)$$

$$ds = \frac{c_p dT}{T} - \frac{v(dP)}{T}$$

$$\boxed{s_2 - s_1 = c_p \ln\left(\frac{T_2}{T_1}\right) - R\ln\left(\frac{P_2}{P_1}\right)}$$

Isentropic Efficiency

$\neq 100$, $s_1 = s_2$

- What ol' Derrick calls "k-equations", k-specific heat ratio which is $\frac{c_p}{c_v}$, which is just 1.4. Unitless.
- What happens to 7-33 when you say isentropic? Left hand side goes to zero, that's what

$$0 = c_v \ln \frac{T_2}{T_1} + R \ln \frac{v_2}{v_1}$$

$$cv \ln T_2 T_1 = -R \ln \frac{v_2}{v_1}$$

- You can use $c_p = c_v + R$ and $= \frac{c_p}{c_v}$ and a bit of handwaving and a smidge of exponentiating

$$\left(\frac{T_2}{T_1}\right) = \left(\frac{v_1}{v_2}\right)^{k-1}$$

- This is (one of many) k-equations.
- Used for $\boxed{T_{2s} = T_1 \left(\frac{v_1}{v_2}\right)^{k-1}}$
  > - We don't solve for T_1 because that's the start so we don't really care.
- Now we need to figure out pressures

$$\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{k-1}{k}}$$

$$\boxed{T_{2s} = T_1 \left(\frac{P_2}{P_1}\right)^{\frac{k-1}{k}}}$$

- Next EES (and Friday) we're going to be dealing with η_{th} and other such fun.

MEGN261 - 2025-02-28

#notes #meche #megn261

Couple Things that Happen Here

1. Sgen of this, sgen of that, yadayada
2. cp/cv, air entropy, etc
3. Isentropic efficiency fun

$$\eta^{(}_T = \frac{\text{actual w}}{\text{ideal w}} = \frac{h_{2a} - h_1}{h_{2s} - h_1}$$

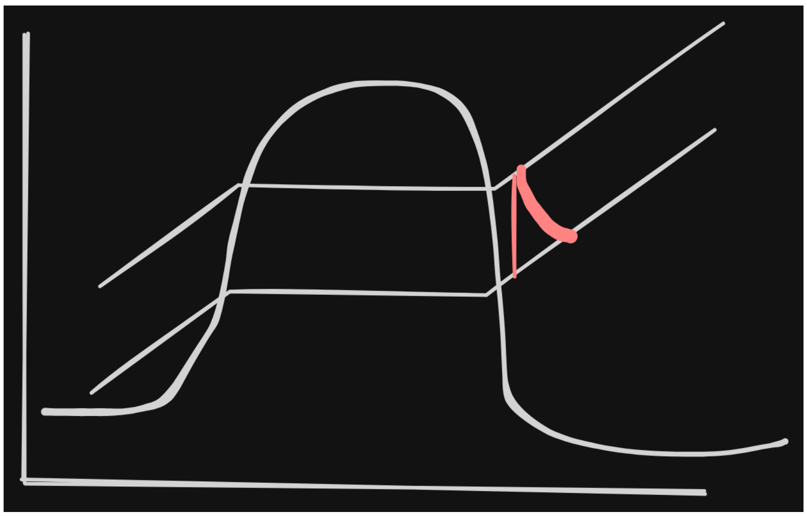
$$\eta_c \text{ or } \eta_p = \frac{\text{ideal w}_s}{\text{actual w}_a} = \frac{h_{2s} - h_1}{h_{2a} - h_1}$$

- S is ideal, a is actual

$$q - w_a = \Delta h + \Delta ke + \Delta pe$$

$$w_a = \Delta h$$

- So now when we're setting up our states



- Constant entropy in the ideal state, so a straight line, less than ideal state it's a moving to the right because of that damn universe thing.

State 1	State 2	State 3
p1 is given	p2 given	p2
t1 is given	s2s is a lookup, but = s1 since ideal	something else
h1 lookup	h2s = (p2,s1) lookup (in EES)	lookup for h2a
s1 lookup		

$$\frac{\cancel{cp}(T_{2a} - T_1)}{\cancel{cp}(T_{2s} - T_1)} \rightarrow \left(\frac{T_2}{T_1}\right) = \left(\frac{P_2}{P_1}\right)^{k-1/k}$$

$$T_2 s = T_1 \left(\frac{P_2}{P_1}\right)^{k-1/k}$$

Seven on the Homework (Compressor Problem)

- We're dealing with Argon as the fluid, which is in fact an ideal gas.
    - First thing to do is get the k value for argon, which is cp/cv, and for argon is 1.667

State 1	State 2 (ideal)	State 3 (ideal)
p1 = 200kPa	p2 = 2MPa	p2 = 2MPa
t1 = 48°C	T2s=??	t2=550°C

- Adiabatic (q=0) , steady state device (d/dt = 0)
- If we're given power, you're probably going to have to solve for output temperature, otherwise assume actual.
- We're using a compressor, so η_C

$$\eta_C = \frac{T_2 s - T_1}{T_2 a - T_1}$$

$$321K\left(\frac{2000kPa}{200kPa}\right)^{\frac{1.667-1}{1.667}} = 806.5K$$

$$\eta_C = \frac{806.5 - 321}{823 - 321} = 0.967 = 96.7\%$$

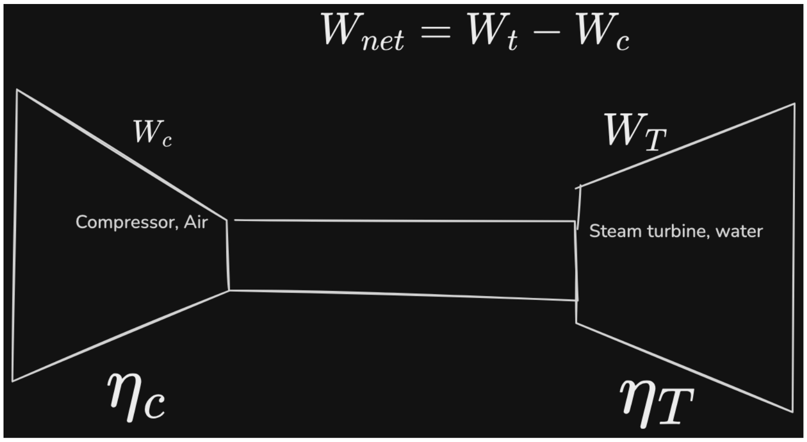
Ok similar compressor vibe, but you gotta actually do lookups with R-134a

- Just do the lookups quick and dirty with EES.
- Refrigerant / Water you look up h1 and s1, p2 h2s, and h2a

MEGN261 - 2025-03-03

#notes #meche #megn261

EES3



- Entropy generated for this system

$$\frac{ds}{dt} = m\Delta s + \frac{Q}{Tb} + S_{gen}$$

- $\frac{ds}{dt}$ is going to be zero, Q is going to be zero (adiabatic), up to you if you want to code them or just drop em out. EES will handle it.
  - Do not use c_p or c_v in EES. The graders will literally kill you.

$$\dot{m}\Delta s = \dot{m}_{air}(s_2 - s_1) + \dot{m}_{water}(s_2 - s_1)$$

```
s_1a = entropy(air, prop1, prop 2)
h_1a = enthalpy(air,T)
```

- Don't do the math yourself! Let EES do it for you. Be *lazy*. Be *free*.

$$\eta_c = \frac{\text{ideal}}{\text{actual}}, \eta_T = \frac{\text{actual}}{\text{ideal}}$$

Big Picture Where the Class is going

- The entirety of the rest of the course is cycles, which is the application.
  - We're doing engines! Internal combustion, diesel, holly jolly.
  - We're going to deal with four states in engines, following the four stroke process.
- Following engines we get into the Brayton cycle, which is a turbo or a natural gas power plant.
  - Starts out at four states, goes to 6-8-10
- Last cycle we cover is the Rankine cycle, which is coal/nuclear power plant
- We dealin with complex systems up in here

    - Lots of focused on being prepared as we can possibly be for a job
    - Also, fuck you Boulder.

Quick Jump Back to Literally Day 1

- I took no notes from this, but weird that it happened.

MEGN261 - 2025-03-05

#notes #meche #megn261

Engine Time

- Bore is the diameter of the cylinder
- TDC (Top Dead Center) is the highest it can go, BDC is Bottom Dead Center and the lwoest it geos
    - Stroke is the distance between them
- Displacement volume is the cylinder of bore by stroke

$$\underbrace{r}_{\text{Compression ratio}} = \frac{\cancel{V}_{BDC}}{\cancel{V}TDC} = \frac{\cancel{V}_d + \cancel{V}_c}{\cancel{V}_c} = 1 + \frac{\cancel{V}_d}{\cancel{V}_c}$$

- Real is an open system, with fuel + air
- us is a closed system, where air is an ideal system
- Dealing with a four stroke, or four state kind of deal
    - Intake is State 1, we've schoomped the air in
    - Compress the everloving shit out of it is state 2
    - Get caboom
    - Reset
- Referred to as the Otto Cycle, after the guy who invented spark ignition engines
    - Exam 2 will have either Otto or Diesel, not both
- Because it's closed, we're using $c_v \Delta t$
- Quick equation cheat sheet maybe

$$r = \frac{\cancel{V}_{BDC}}{\cancel{V}_{TDC}} = \frac{\cancel{V}_1}{\cancel{V}_2} = \frac{\cancel{V}_4}{\cancel{V}_3} \rightarrow \frac{T_2}{T_1} = \frac{T_3}{T_4} = r^{k-1}; \rightarrow \frac{T_4}{T_1} = \frac{T_3}{T_2}$$

$$\eta_{\text{th,otto}} = \frac{W_{net}}{Q_{in}} = \frac{Q_{in} - Q_{out}}{Q_{in}} = 1 - \frac{Q_{out}}{Q_{in}} = 1 - \frac{mc_v(T_4 - T_1)}{mc_v(T_3 - T_2)} = 1 - \frac{(T_4 - T_1)}{(T_3 - T_2)} = 1 - \frac{}{r^{k}}$$

- For air, k=1.4, R = .287, c_v is 0.717
- Max temperature and pressure is state 3. It's a bomb. 💣

Oooookie dokies wtf does this actually look like in a problem

- At the beginning of compression, $r = 9$, this is state 1 type information. We never back calculate state 1
- Heat addition to the air is 1kJ
- Max temperature in the cycle is 750
- Hold on state 4 until the problem says to
- We're looking for net work, W_{net}, thermal efficiency, η_{th}, and MEP
  - If you have r that's thermal efficency
  - MEP is Mean Effective Pressure in kPa
    - which is $\frac{W_{net}}{\cancel{V}d}$

State 1	State 2	State 3	State 4
$p_1 = 95$		$T = 750^{\circ}$C	
$t_1 = 30^{\circ}$C	T_{2s}		T_{4s}

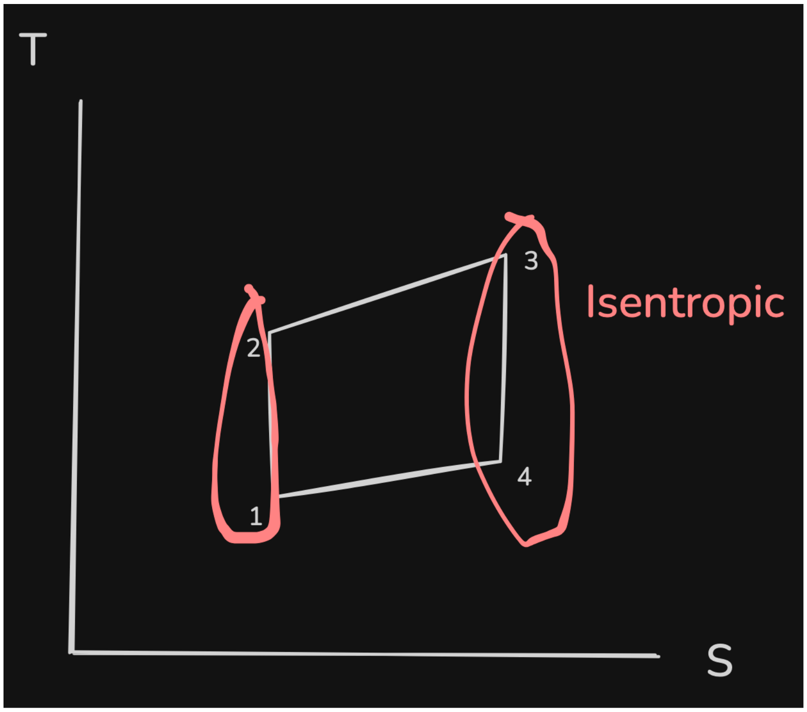
- Using k equations $s_1 = s_2$, $s_3 = s_4$
- So we're dealing with air, so k=1.4, $c_v = 0.717$, R=0.287
- r is $\frac{v_1}{v_2}$
- We can only really get W_{net} through like $Q_{in} - Q_{out}$ or dealing iwth all of our temps

$$Q_{in} = mc_v(T_3 - T_2)$$

- Mass is .005 kg
  - And we add 1kj to the air
  - $1 = (0.005)(0.717)(T_3 - T_2)$
  - If we weren't given Q we would use k equations to solve for it
  -

MEGN261 - 2025-03-07

#notes #meche #megn261



- This drawing is shit. T_4 is allowed to be higher than T_2
- Single cylinder engine with bore 12mm and stroke 50cm, using Otto cycle
- Q_{2-3} is combustion, Q_{4-1} is exhaust

State 1	State 2	State 3	State 4
Always given!	Ideal temp T_s, use k equations	Relates combustion T+P, is max/highest	k equation, but be lazy and don't do it unless asked.
$P_1 = 100kPa$			
$T_1 = 25$C		$T_3 = 1100$	

- If the clearance volume is 1500cc
  - bro 200cc is fast (mario akrt core)
- We're looking for cycle efficency, η_{th}
- At 300 RPM, what is the engine output in kilowatts
- Figure out mass
- Q_{in}
- Q_{out}
- We need some constants, $c_v = 0.717, R = 0.287, k = 1.4$

$$\eta_{th} = 1 - \frac{1}{r^{k-1}}$$

$$V_1 = \underbrace{\frac{\pi D^2}{4}L}_{\text{Displacement}} + \overbrace{\underbrace{1500cc}_{\text{Clearance}}}^{V_2} = 7,145.8cc$$

$$m = \frac{P_1 \cancel{V}_1}{R(T_1 - k)} = \frac{(100)(7,154.8 * 10^{-6})}{.287(273+25)} = 0.00837kg$$

$$r = \frac{\cancel{V}_1}{\cancel{V}_2} = \frac{7154.8}{1500} = 4.7$$

- Oh hey, now we have r and can go nuts with the rest of the problem

$$\eta_{th} = 46.7\%$$

$$\eta_{th} = \frac{W_{net}}{Q_{in}} = \frac{Q_{in} - Q_{out}}{Q_{in}}$$

$$Q_{in} = mc_v(T_3 - T_2)$$

$$T_{2s} = T_1(r)^{k-1}$$

$$T_2 = (25+273)(4.7)^{1.4-1} = 557K$$

- Sure. Don't run the numbers.

$$Q_{in} = 4.89\ kJ$$

$$\eta_{th} = \frac{W_{net}}{Q_{in}} = 0.467 = \frac{W_{net}}{Q_{in}}$$

$$\dot{W}_{net} = n_{cyl} * W_{net_{each}} = n_{cyl} * \frac{\frac{rev}{\text{sec}}}{2} * W_{net}$$

$$W_{net} = (4.8)(0.467) = 2.24 = 11.2kW$$

$$\frac{T_4}{T_3} = \frac{T_3}{r^{k-1}} = 734K = T_4$$

$$Q_{out} = mc_v(T_4 - T_1)$$

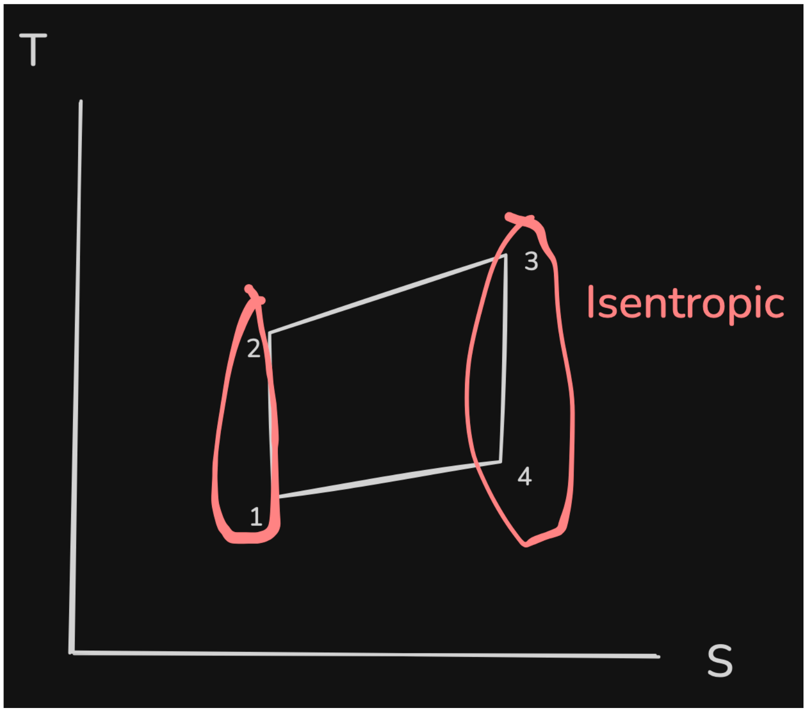
MEGN261 - 2025-03-10

#notes #meche #megn261

Engines! Of the Diesel variety

- Rudolf Diesel was the guy who invented diesel engines (crazy)
- There's no spark plugs, all just based upon compressing the shit out of it until it go kabloomy

- Diesel fuel vs gasolien
- r is much higher for diesel, we can go well above 20
  - 8-13ish for otto engines
- r_c is the cutoff ratio
  - (new term)
- $\cancel{V}_{co}$ is cutoff volume
  - diesel exclusive term



- This is just the exact same model
  - Diesel's gimmick is that between 2 and 3, $p = c$ (constant pressure)

```
Qin = enthalpy()
Qout = intenergy()
temperature()
```

- Using these instead of c_v and c_p for EES
- Industries that use Diesel
  - The tiny little baby industries, like
    - Shipping
    - Agriculture
    - Construction
    - Mining
    - Boats
    - Generators

        - Consumer Diesel
- Why diesel for consumer cars?
    - MPG from 40-60, which is neat
    - Torque's neat! Gets you up the mountain
    - Biodiesel
        - Fast food trash makes great fuel
        - does in fact decrease miles per gallon, but you can make it in your garage
- Why is Diesel kill?
    - Lobbyists.
    - Consumer demand ain't there
        - Strict regulations
        - PR!
            - What complaints do people have?
                - Smell. Stinky.
                    - We've solved that problem, it was an engineering issue with an engineering solution
                - Visual
                    - Black smoke
                - Rough times starting
                    - Computers and glow plugs solve that problem
        - Diesel fuel is more expensive
        - Maintenance is... maybe? More expensive? Depends
- Looking at a diesel problem, maybe?
- We still have four states!

State 1	State 2	State 3	State 4
Still the given!	Still use k-equation		

- How your r works, top dead center, bottom dead center is still all the same

$$\underbrace{r_c}_{\text{Cutoff ratio}} = \frac{\cancel{V}_{co}}{\cancel{V}_{TDC}}$$

$$n_c * \frac{N}{2} = W_{net}$$

$$\eta_{th,Diesel} = \frac{W_{net}}{Q_{in}} = \frac{T_1\left(\frac{T_4}{T_1} - 1\right)}{kT_2\left(\frac{T_3}{T_2} - 1\right)} = 1 - \frac{1}{r^{k-1}}$$

$$\frac{T_3}{T_4} = \left(\frac{r}{r_c}\right)^{k-1}$$

- There's a frankly gross amount of equations that are lowkey hard to see

---

Example problem

- 4 cylinder 3L diesel engine, operates with an ideal diesel cycle and a compression ratio of 18 and a cutoff ratio of 3, with $T_1 = 25$ and $P_1 = 95$ mk how much power will the engine deliver at 1700 rpm

$$r = 18, r_c = 3$$

- We're looking for $\dot{w}_{net}$

State 1	State 2	State 3	State 4
$T_1 = 25C$	$T_{2s} = T_1 r^{k-1}$ $T_{2s} = 947K$	$T_3 = T_2 r_c$	$\frac{T_3}{T_4} = \left(\frac{r}{r_c}\right)^{k-1}$
$P_1 = 95$kPa			

- We need some constants rq
  - $c_v = 0.717$, $c_p = 1.4(?)05$, $k = 1.4$, $R = 0.287$
- Mass is $\frac{PV}{RT} = \frac{95\left(\frac{3*10^{-3}}{4}\right)}{0.287(25+273)}$ which si then some

$$r_c = \frac{v_3}{v_2} = \frac{T_3}{T_2}$$

- Remember for Diesel only P2=P3

$$w_{net} = Q_{in} - Q_{out}$$

$$= mc_p(T_3 - T_2) - mc_v(T_4 - T_1)$$

$$\dot{w}_{net} = 4 * \frac{\left(\frac{1700}{60}\right)}{2} * w_{net}$$

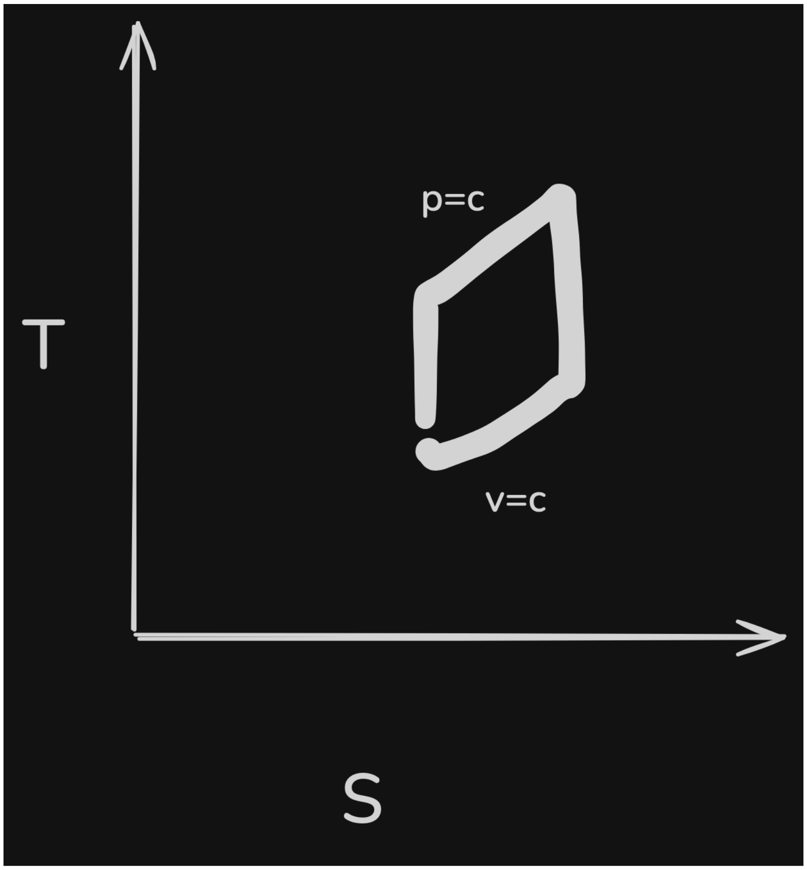
- Do recall that the /2 is for 4 stroke engines

MEGN261 - 2025-03-12

#notes #meche #megn261

Housekeeping

- No class Friday
- No homework over break, stuff due tonight/tomorrow



$$\frac{dh}{dt} = cp, \frac{du}{dt} = cv$$

$$dh \approx cpdt, du \approx cvdt$$

$$q_{23} = q_{in} = h_3 - h_2$$

- Do that instead of c_p or c_v. If the grader sees cp cv you will be shot

$$q_{out} = q_{41} = u_4 - u_1$$

- Vertical line,

```
s1=s2
s3=s4
p2=p3
v1=v4
q_in=h3-h2
q_out= u4-u1
w_net = q_in - q_out
```

```
eta_th = w_net / q_in

---
Function calls (Air vs Air_ha)
    (air_ha is the more complex one, just use air)
Enthalpy/Internal energy for Air with 1 property

enthalpy(air)
intenergy(air)

temperature()
pressure()
volume()

r=v1/v2
entropy()
```

Brayton Cycle

- At the big end, this is the model for a natural gas power plant
    - At the little end, this is a turbocharger in a car
- Once we pop into the Rankine cycle, we'll deal with combined plants(that use both coal and natural gas)
- We look at cycles three ways, ideal, actual, and mods
- Ideal brayton is just air, which is on the same shaft as your turbine
- We model combustion q as the top heat exchanger, and

$$BWR = \frac{W_c}{W_t}$$

- When we switch from ideal to actual, we assign isentropic efficiencies to the turbines and compressor

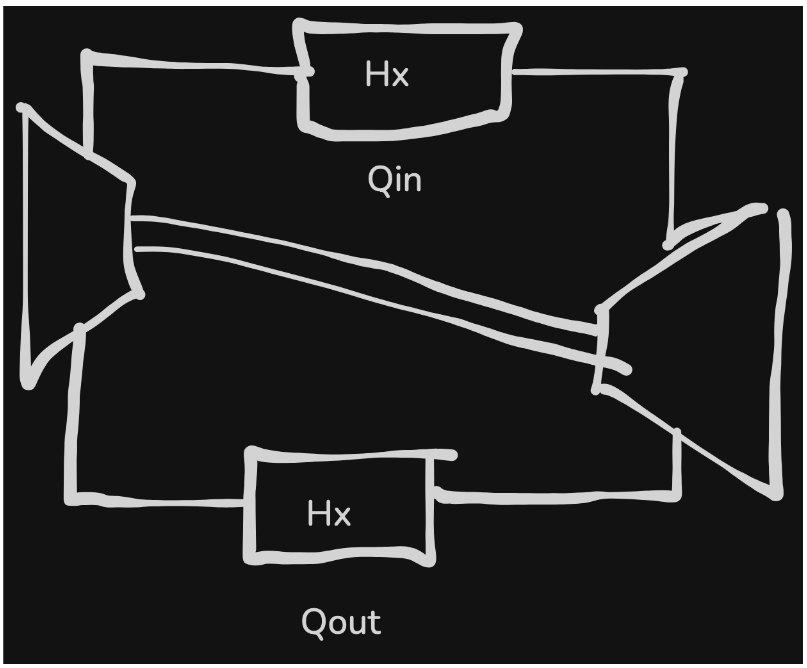
MEGN261 - 2025-03-24

#notes #meche #megn261

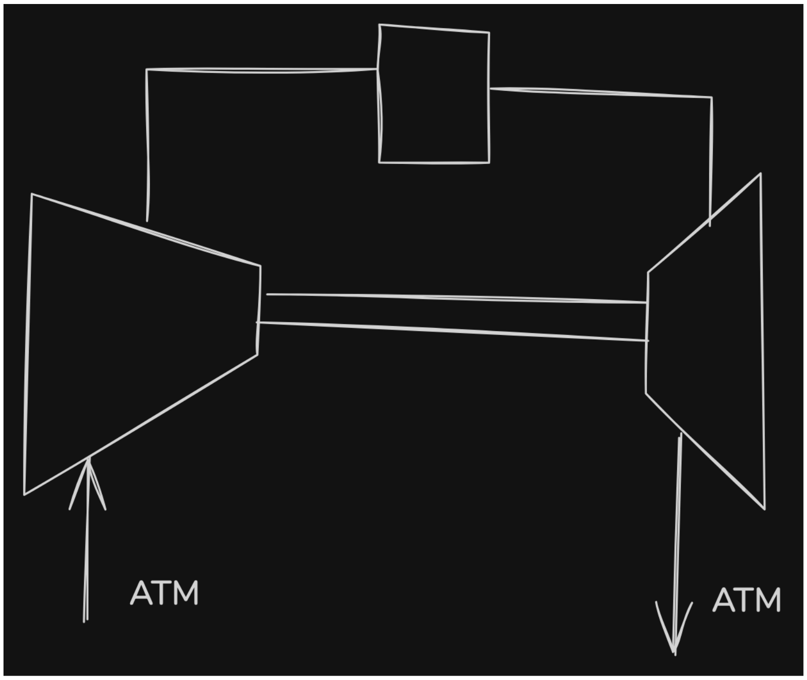
Housekeeping

- Project is assigned Wednesday, work in groups of two
    - Project is going to be modeling the campus power system with solar or some other shenanigans

Anyways, back to Brayton

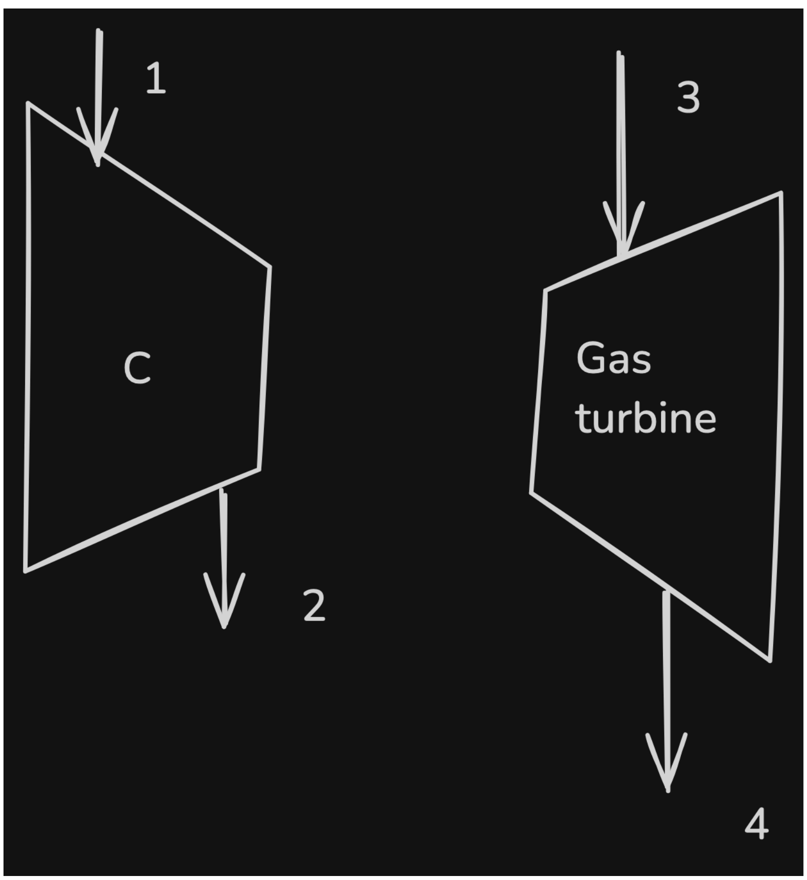
- We mean the ideal, basic bitch brayton cycle when we say Brayton ideal
  - We use ideal gas, we use constant specific heats, we use k-equations, it's a grand old time
  

- the shaft is a little floppy



Actual Brayton

$$\eta_c < 1, \eta_t < 1$$



$$\eta_c = \frac{ideal}{actual} = \frac{\overbrace{h_2s - h_1}^{EES}}{h_2a - h_1} = \frac{c_p(T_{2s} - T_1)}{c_p(T_{2a} - T_1)}$$

- To review
  - T_1 is given
  - c_p is given
  - $T_{2s} = T_1 \left(\frac{P_2}{P_1}\right)^{k-1}$

$$\eta_T = \frac{actual}{ideal} = \frac{h_3 - h_{4a}}{h_3 - h_{4s}} = \frac{T_3 - T_{4a}}{T_3 - T_{4s}}$$

Time for Mod(ifications)s

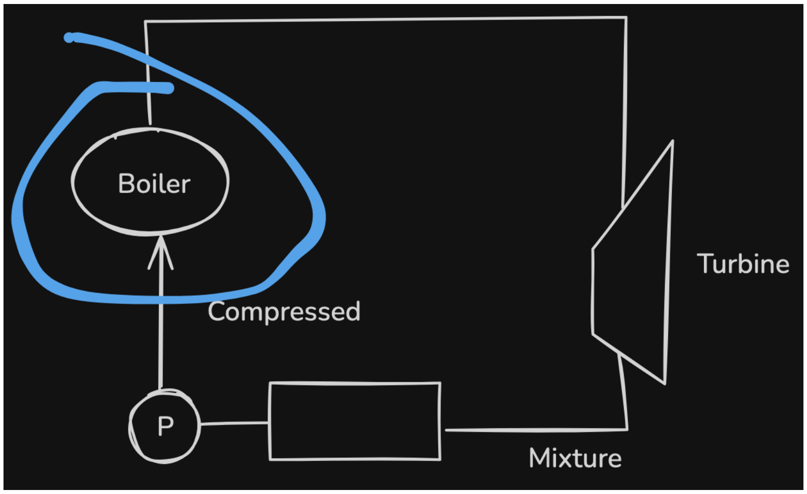
- Design Criteria are generally
  1. More power
  2. Meet current η_{th} of the cycle or better
     - η_{th} translates into money.
  3. Operation and maintenance
     - That's what we in the business call an outage
  - Cost $$$$$$$
- We're currently lobbing some pretty toasty air out the other side of our gas turbine, which is waste heat, lost work, or exergy
  - We're just going to put another combustion chamber (heat exchanger, for us) after the waste heat to heat it back up to where we actually can use it.
- $$w_{net} = W_{t_1} + W_{t_2} - W_c$$
  $$\eta_{th} = \frac{W_{T_1} + W_{T_2} - W_{c_2}}{Q_{in_1} + Q_{in_2}}$$
- Hey, if we need two combustion chambers, we almost certainly need more air, which is going to be achieved through multi-stage compression
- Regeneration puts some extra heat inbetween the compressor and the combustion chamber

$$W_c = W_{ext} = \dot{m}(h_2 - h_1)$$

MEGN261 - 2025-03-26

#notes #meche #megn261

- Little baby part of a Rankine cycle



- Post Coors, Pre-2023 CSM power plant, our boiler friend is named Buzz.
- If you don't understand something, hit a quick google
- Draw a picture that makes sense to you (control volume)
- Use the numbers given in the diagram

$$\dot{Q} - \dot{w} = \dot{m}(\Delta h + \Delta ke + \Delta pe)$$

$$\frac{ds}{dt} = \dot{m}\Delta s + \frac{\dot{Q}}{T_s + s}$$

$$COM = \dot{m} \rightarrow \frac{dm}{dt}$$

- Do all the equations, NOT IN EES, jsut all psuedocode.
-

MEGN261 - 2025-03-28

#notes #meche #megn261

Today's the Last Day of Content before Exam 2

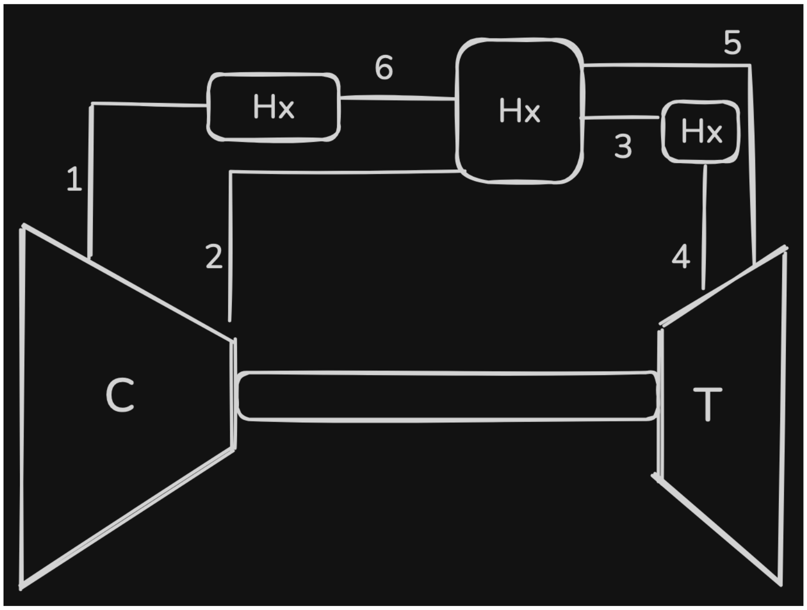
- Fixing old Buzz would cost between 20 and 40 million, so it's probably taking a dinosaur's route. (Projet note)
- Regenerator effectiveness

$$\epsilon = \frac{\dot{Q}_{regen}}{Q_{regen,max}} = \frac{\dot{m}(h_6 - h_2)}{\dot{m}(h_5 - h_2)} = \frac{h_6 - h_2}{h_4 - h_2}$$

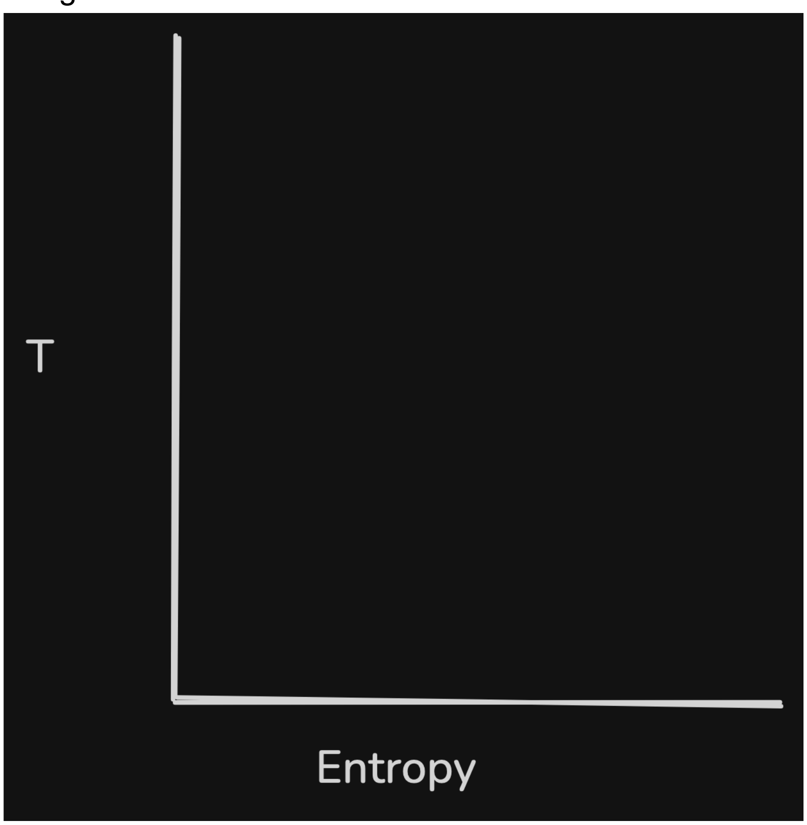
- Pg model means use constant specific heat

$$\epsilon = \frac{h_6 - h_2}{h_5 - h_2} = \frac{c_p(T_6 - T_2)}{c_v(T_5 - T_2)} = \frac{T_6 - T_2}{T_4 - T_2}$$

Number 4 on da homework



- We got six states! And that's it!



- A gas turbine for an automobile is designed with a regenerator. What? Air enters the compressor at 100kPa and 30C. Max temp is 800C, cold air stream leaves regenerator at 10C cooler than the hot airstream at the inlet of the regenerator

State 1	State 2	State 3	State 4	State 5	State 6
$P_1 = 100$	$P_2 = 8 * P_1$				
$T_1 = 30$			$T_4 = 800$		

- $r_p = \frac{P_2}{P_1} = 8$ P_2 is higher than P_1, which is crazy.
- $s_1 = s_2$, $s_4 = s_5$
  - $\eta_c = 1, \eta_t = 1$

$$\dot{Q}_{in} = \dot{m} * c_p(T_4 - T_3)$$

$$\dot{Q}_{out} = \dot{m}c_p(T_6 - T_1)$$

- Power is 105 kW = $\dot{W}_{net}$

$$\dot{m} = \frac{\dot{W}_{net}}{w_{net}} = w_t - w_c = c_p(T_5 - T_4) - c_p(T_2 - T_1)$$

$$T_2 = T_2 \left(\frac{P_2}{P_1}\right)^{k-1/k}$$

$$T_5 = \frac{T_4}{\left(\frac{P_2}{P_1}\right)^{k-1/k}}$$

- Also,

$$c_p = 1.005$$

$$k = 1.4$$

- Riddle shenanigans

$$T_5 - T_6 = T_3 - T_2$$

$$T_3 = T_5 - 10$$

MEGN261 - 2025-03-31

#notes #meche #megn261

Housekeeping

- Exam is next Tuesday!
- There are four questions. That is, in fact, still terrifying.
  1. Chapter 6 (exam 1 practice tpye shit) with any fluid

2. Chapter 7/8, with any fluid
3. Otto or diesel, with air
4. Brayton cycle with air
    - No rankine!

- We have two more quizzes that are going to smuggle themselves in before the end of semester, they're going to be in-class
- Boiler is Q_{in}
- Condenser is Q_{out}
- $\dot{w}_{net} = \dot{w}_t - \dot{w}_p$
- $\eta_{cycle} = \frac{\dot{w}_{net}}{Qin}$

Combined power plants are a thing that exists

- Which is Rankine + Brayton
    - Someone got the wise idea of putting the positives of both together, which, shockingly, works pretty well.
    - We're dumping the coal out of the Rankine
- Mods on Rankine are weird because we have lookups
    - Reheat, works the same as Brayton
    - Regen is going to be like a full week, but we have closed and open feedwater heaters
        - For both of those we have to take a bleed, because we're essentially the only source of power/heat, so we gotta rob it from somewhere.
    -

MEGN261 - 2025-04-07

#notes #meche #megn261

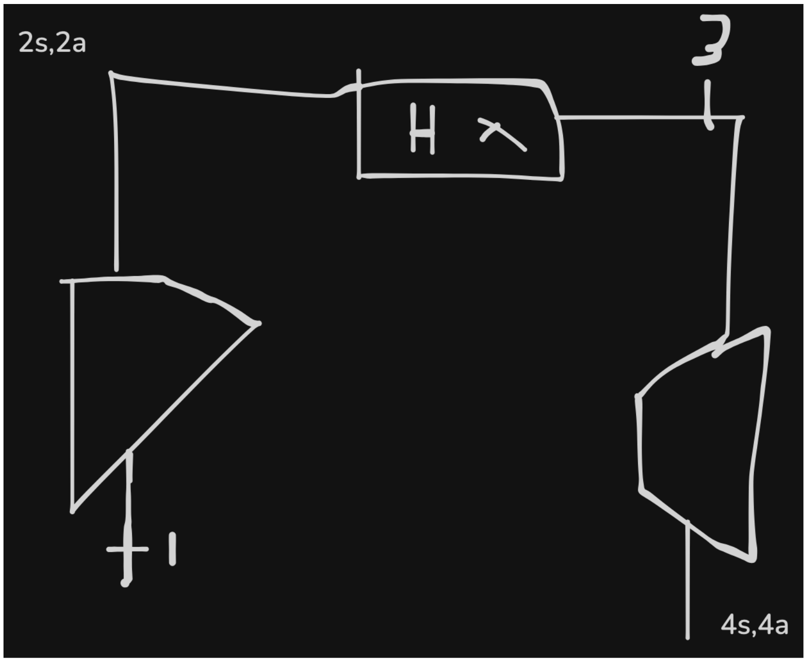
Housekeeping

- All homework solutions are posted, no class friday, rooms are posted
- We're in Berthoud 108
-

Brayton Review

$\dot{Q}_{in} = \dot{m}c_p(T_3 - T_2)$
$\dot{W}_c = \dot{m}c_p(\Delta T)$
$w_c = c_p(\Delta T)$

- If Brayton (ideal) is on the exam, that should be the most comically free points of all time



- If we're given η_t and η_c, we're going to find the actual temps
- If we're asked for efficiencies, we need to find our temps and make sure η is less than 1.

$$\eta_c = \frac{ideal}{actual} = \frac{T_{2s} - T_1}{T_{2a} - t_1}$$

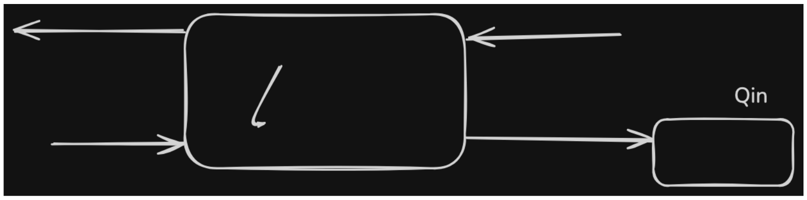
$$\eta_t = \frac{actual}{ideal} = \frac{T_{4a} - T_3}{T_{4s} - t_3}$$

- Use actual on everything if you have actuals.

Mods

- Reheat
  - Reheat is literally just two combustion chambers and two turbines.
    - $w_{net} = w_{t_1} + w_{t_2} - w_c$
    - $Q_{in} = Q_{in_1} + Q_{in_2}$
    - $\eta_{th} = \frac{w_{net/}}{Q_{in}}$
- Regen, we literally just have a hot pipe and a cold pipe thing

- Hot goes to the cold



$$\text{Effectiveness} = \frac{Q_{regen}}{Q_{regen,max}} = \epsilon$$

- ϵ is how much of the hot makes it to the cold
- If ϵ is given, we use our equation to figure out the temperature
- If we have to find it, then we need to determine our temperatures and more has to be given.

Rankine is not on the exam, but it will be half of the final. Godspeed.

MEGN261 - 2025-04-18

#notes #meche #megn261

MEGN261 - 2025-04-25

#notes #meche #megn261

Housekeeping

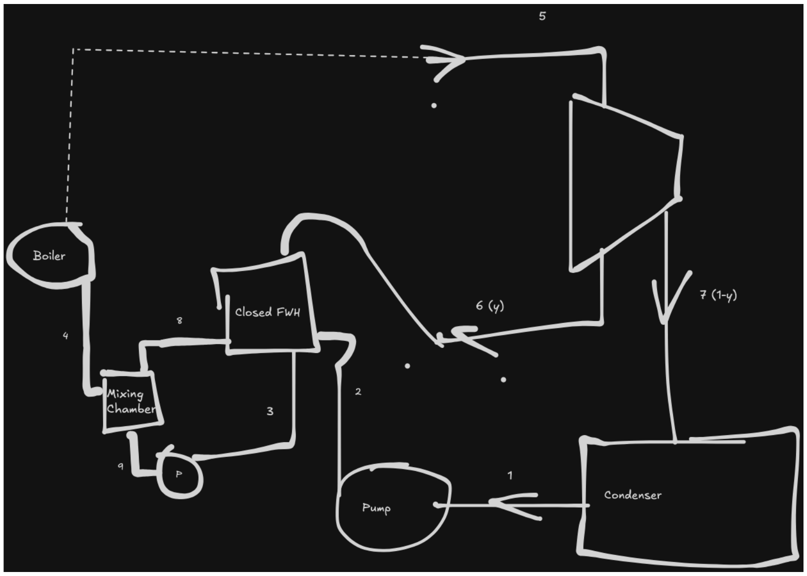
- Finish up Rankine today, then review on Monday/Wednesday

Assorted Other Rankine Notes

- Mostly working with feedwater heaters today
  - Including the homework problem, neat

Traps

- What a trap does is trap the condensate from the pressure drop across the trap, enthalpies are the same though



$$w_{net} = wt - wp_1 - wp_2$$

$$\eta_{th} = \frac{w_{net}}{Qin}$$

$$Q_{in} = h_5 - h_4$$

$$w_{p_1} = (1-y)(h_1 - h_2)$$

wp{2}=h{3}-h_{4}

$$COEAcrosstheClosedFW$$

\dot{m}{6}(h{6}-h{3})=\dot{m}{2}(h{2}-h{8})

$$-Bleed, \$y = \frac{\dot{m}_6}{\dot{m}_5}\$$$

y(h{6}-h{3})=(1-y)(h{2}-h{8})

MEGN261 - 2025-04-28

#notes #meche #megn261

Housekeeping

- Homework tonight, project wednesday,

- Final is going to be four questions
  - Two rankine questions, two others
    - One of the Rankines is going to be an open or closed feedwater heater
      - Reheat/ideal/actual are all options for the other rankine
    - The Two Others
      - Totally not going to be chapters one, two, or three, because you need em for everything else
        - Probably skip chapter five, open systems, which has been compressors, pumps, heat exchangers, won't be there
      - Could be:
        - Chapter 4, ie tanks, piston cylinders, other closed systems
        - Could also totally be chapter 6 (carnot/cop), chapters 7 & 8 with entropy, engines on chapter 10, etc
  - Happy Birthday, from one to three PM.

Lots of Exam Review

- Know your open and closed, especially for rankine
  - Closed is per pipe for pressures, open system all has the same pressures
- What will you get provided on the exam?
  - We'll get the process diagram
    - So having the T-S diagram is awesome, because it tells you phase, pressure, etc
    - Equations, which is great for knowns/uknowns
  - On more complicated problems, we'll get the state table that drod so loves to draw every time
- *Please* pay attention to units, it tells you so much and is such a free way to not fuck it up.

Quiz on Wednesday if you show up

MEGN261 - 2025-04-30

#notes #meche #megn261

Entropy

$$\Delta S = cp \ln \frac{T_2}{T_1} - R \ln \frac{p_2}{p_1}$$

$$\Delta = cv \ln \frac{T_2}{T_1} + R \ln \frac{v_2}{v_1}$$

- cp is for open, cv is for closed
  - This feels like a not so subtle exam hint.
- Water is lookups
- Sgen is $\frac{ds}{dt} = \dot{m}\Delta s + \frac{\dot{Q}}{Ts} + Sgen$

Quick bit on Chapter 4 (Closed systems)

- That's internal energy

The fuckass house problem

- It has a $Qout$ of 50,000 kj/hr
- The inside temp needs to be 22C for 10 hours
- It's heated by 50 glass containers that are each 20L at 80C
- There's an electric heater at 80 kw to pick up the slack
- Blah blah blah blah, blah blah, blah blah blah blah. I didn't really want to pay attention. Do the math, it'll be on the exam, probably, given that he bothered to talk about it.
  - Easiest way to simplify this is to do units and just let those be your guiding light.
-

MEGN261 - 2025-05-06

#notes #meche #megn261

Mines is cold in the winter, outside temperature of 0C (boundary temp for later), room is currently 10C and we want it to be 20C. Heated by an electric heater at 120V and 15A, the heater also has a fan of 150W to distribute hot air around the room. The room loses heat at 500W. The room has dimensions of 4x5x7. The air is an ideal gas, the room is sealed and all doors are closed, and room is empty. Starting pressure is 100 kPa

1. Is this a closed system? Why?
2. Derive the equation explictly for change in time

$$\Delta E(10C \rightarrow 20C) = (120 * 15) * \Delta t - 500 * \Delta t - 150\Delta t$$

$$\Delta E(10C \rightarrow 20C) = \Delta t(1800 - 500 - 150)$$

$$\Delta E(10C \rightarrow 20C) = \Delta t(1150)$$

$$\Delta t = \frac{\Delta E}{1150}$$

3. Solve for how long it takes to heat the room
4. Solve for Sgen

- Early jet engines could be simplified to a brayton cycle, except input (density?) is 1/5 what standard conditions would be because of high altitude. etc for a brayton cycle with a peak temperature of 600?, input temperature of {some air temperature}, and volumetric flow rate of 1.2 m^3 /s, pressure ratio of 8

1. Find ρ of the air (density, kg/m^3)
2. Find $\dot{m}$ of the air
3. Find wnet
4. Find Qin and BWR