APSC 101

Week 1 Video 1: Safety and Hand Tools

- Learning goals
  - Describe basic safety protocols for working with handtools
  - Name all of the tools used in Module 5, and describe the function and operation of each
  - Identify which tools were used to create various features in components
- Studio expectations
  - PPE including closed toe shoes, long pants and safety goggles
  - Safety goggles
    - Worn at ALL TIMES. Eyeglasses are not alternatives
    - Encouraged to bring our own
  - Injuries
    - Minor injury: notify instructor. Get bandage if necessary.
    - Serious injury: notify instructor, call 911 and stay on line, have someone wait outside EDC for paramedics
- Hand tools
  - Aviation Snips or Shears
    - Two types that are mirror images
    - Used like scissors to cut sheet metal
    - Do **not** cut wires
    - Often, one tool is easier to use in a particular direction
    - Curved cuts (waves, circles) are also possible
  - Pliers
    - Used to cut wires
  - Seamer (sheet metal pliers)
    - Used to make a straight fold in sheet metal
  - Nibbler
    - Insert sheet metal to "nibble" a small piece from the sheet
    - Nibbles out straight lines and slots
  - Hole Punch
    - For most people, easier to use upside down
    - Mark holes with cross hairs
    - Locate position and punch hole
    - If sheet metal becomes stuck, rapidly pull apart handles
  - Pop Riveter (Riveting tool)
    - Use the first piece to transfer holes to the second piece
    - Used to hold 2 sheets together **permanently**
    - Push the pop rivet back into the riveting tool after every squeeze

- Pull out the mandrel (long pin) before each use

Week 2 Video 1: Managing Risk

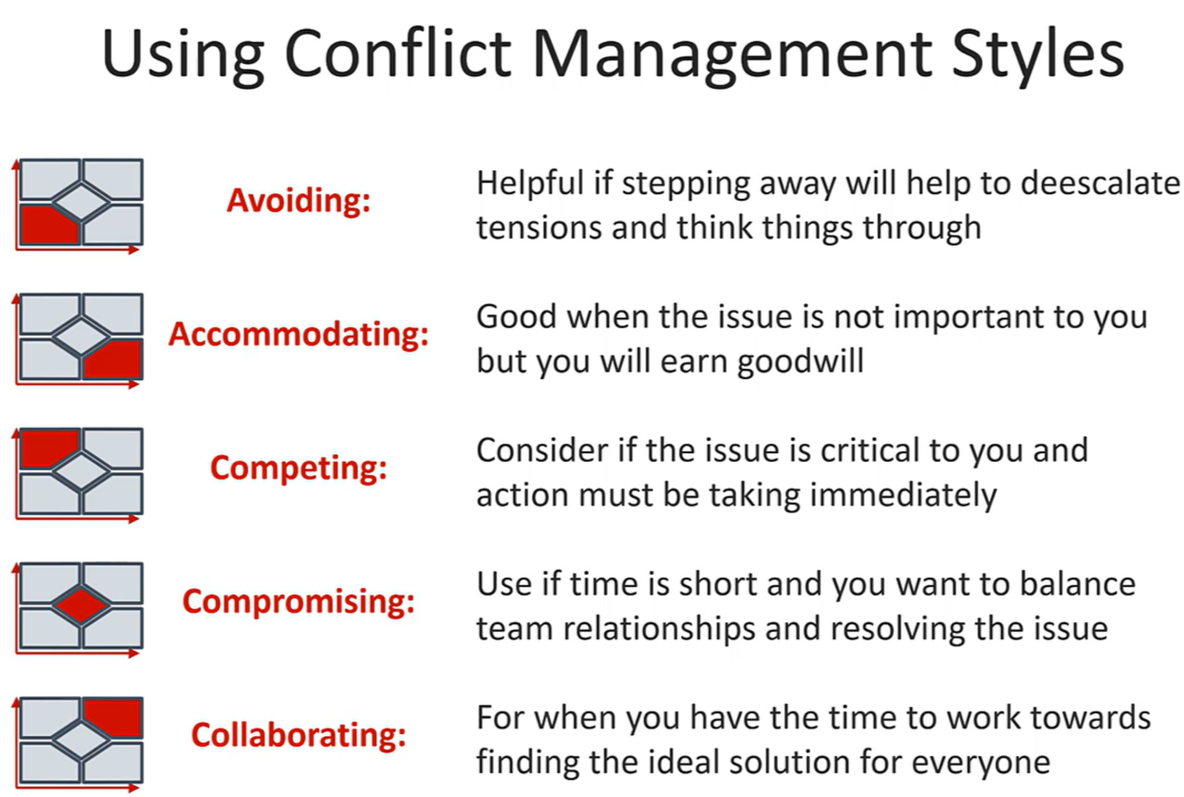
- Learning goals
  - Define the term "risk"
  - Describe the factors that determine risk
  - Classify risks by common sources and categories
  - Explain what a risk matrix is and how it is used
  - Describe the risk management procedure
- Risk = Severity * Likelihood. Risk is the possibility of injury, loss, or damage
- Sources of risk
  - Preventable risks: within team control
  - Strategic risks: risk with possibility of reward
  - External: outside of control, but must be considered
- Risk Categories

- Risk classification
  - Risk source vs risk category
- Risk management strategies
  - Avoid (best but often unable)
  - Mitigate (minimize likelihood or severity)
  - Transfer (pass risk to others, i.e. insurance)

    - Accept to live with consequences
- Safety is **paramount**
- Risk matrix
    - Severity (1 to 5) and likelihood (1 to 5). Risk is the product (from 1 to 25)
- Procedure: Identify risk -> risk analysis -> is risk acceptable? (risk matrix). Either accept, avoid/transfer, or mitigate

Week 2 Video 2: Team Development

- Learning Goals
    - Describe the different stages of typical team development (Tuckman model)
    - Identify key features of effective engineering teams
    - Describe the benefits and costs of conflict on a team
    - Identify appropriate conflict management strategies to use in various team situations
- Tuckman's Stages of Team Development
    - Completion of tasks vs team relationships
    - Forming: politeness, uncertainty, optimism. Lack of clear goals, people try to help. Team members work as individuals
    - Storming: members feel more willing to speak. Leads to conflict, tension, stress. Quality and quantity of work diminishes
    - Norming: consensus built, roles established, standards set
        - Updated model: good and bad norming. Bad norming is where bad norms like skipping meetings comes to be accepted
    - Performing: successful performance, openness, trust established
- Transition between stages
    - Conflict: always present, but is out in the open and more intense during storming
    - Forming -> storming: time spent building team relations, leadership established
    - Storming -> norming: open communication, desire to get better as a team
    - Norming -> performing: environment where people feel safe to speak their minds. Value on the team over the individual
- Norms
    - Bad team norm if a teammate doesn't show up and that is just accepted
- Conflict management styles
    - Assertiveness (achieving own needs) and cooperativeness (achieve other's needs)



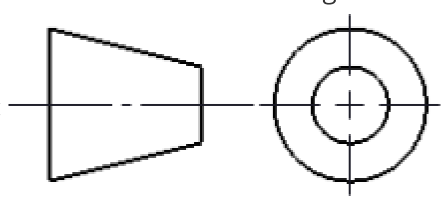
- Suited to different situations
- Best to be flexible and adaptable

Week 3 Video 1: Isometric and Orthographic Projection

- Learning goals
    - Describe what is meant by "projection" in the context of engineering drawings
    - Explain how isometric and orthographic projection drawings are produced, and the pros and cons of each
    - Explain why hidden lines are used in orthographic drawings
    - Interpret isometric and orthographic drawings
- Projection: view of 3D object on 2D plane
- Isometric Projection
    - Oblique view from one corner
    - Properties
        - Vertical lines are vertical
        - Horizontal axes rise at 30 degrees to horizontal on the page
        - Equal distant along axes have equal distance on the page
        - Parallel lines are parallel (different from perspective)
            - In perspective, parallel lines converge to vanishing point
    - Sketching Isometric Projections
        - Lightly sketch enclosing box(es)

        - Draw shape
        - Erase box
- Orthographic Projection
    - Front, End, Top, Other End, Bottom, Back views
    - Typically use three: Front, Top, and one of the Ends
    - Hidden lines: dashed lines that reveal features on the inside or back of the part
    - Centerlines (long short dashes): used to identify center of circles and axes of cylinders

Week 3 Video 2: Engineering Drawings - Layout and Dimensions

- Learning goals
    - Describe what is meant by "Third Angle Projection" and be able to arrange orthographic views in accordance with it
    - Describe what a "title block" is and how it is used on an engineering drawing
    - Describe the standards of dimensioning engineering drawings and identify dimensioning errors
- Third Angle Projection (used in North America)
    - Unfold three standard orthographic views
    - Front view and top view align, front view and end view align
    - Third angle projection symbol: 
- Title Blocks
    - Border: numbers and letter provide a way to reference regions of the drawing
    - Third angle projection symbol is included in the title block
    - Information included
        - Drawing name
        - Drawing number
        - Revision number/letter
        - Drawing scale
        - Who prepared/checked drawing
        - Detail on units and precision of dimensions
- Dimensions
    - Dimensions indicate length/size
        - Dimension (# of units)
        - Dimension line with arrows on both sides
        - Extension line (comes close to object but does not touch)
    - Guidelines
        - Draw dimensions **outside** of the view of the part
        - Do not show **redundant** dimensions
        - When possible, place dimensions between views

        - Dimension the view that most clearly shows the feature
        - Extension lines may cross, dimension lines may not

Week 4 Video 1: Giving and Receiving Feedback

- Learning goals
    - Recall three types of feedback in the workplace (from module 4)
    - Describe how the 7 Cs of communication relate to face-to-face feedback
    - Describe the 3x3 Model of Feedback and how it applies to face-to-face feedback
- Types of feedback
    - Appreciation: appreciation for job done
    - Coaching: help someone improve
    - Evaluation: rate someone against standards
- Clear, Correct, Concise, Concrete, Complete, Courteous, Considerate
- Sender, Receiver. Message, Response
- 3x3 Model
    - Message
        - Concrete (descriptive, specific, non-judgmental)
        - Complete (details but also suggestions and impacts)
        - Considerate (empathetic and relevant)
    - Sender
        - Clear (consistent, unambiguous language)
        - Courteous (sincere and polite)
        - Considerate (choose time and method of delivering feedback)
    - Receiver
        - Clear (consistent, unambiguous language)
        - Courteous (receptive, respectful)
        - Complete (acknowledge feedback and request clarification as appropriate)

Sender	Message	Receiver
Clear consistent, unambiguous speech and body language	**Concrete** descriptive, specific, and non-judgmental; focuses on receiver	**Clear** consistent, unambiguous speech and body language
Courteous polite and respectful tone, language, and body language	**Complete** includes observations, impacts, and suggestions for improvement	**Courteous** receptive; polite and respectful tone, language, and body language
Considerate consider receiver when choosing time and method of feedback	**Considerate** is empathetic and relevant to the receiver	**Complete** acknowledge the feedback; ask for clarification

Week 4 Video 2: Top Performing Teams

- Learning Goals
  - Describe the characteristics of relationships on top-performing teams
  - Describe what equity, diversity, and inclusion (EDI) are and how they impact teams
  - Define implicit bias, stereotype threat, microaggressions, and psychological safety
  - Describe the origins and consequences of bias
  - Explain how psychological safety relates to team performance
- Equity, Diversity, and Inclusion
  - Equity: making sure everyone has similar opportunities to success
    - Different from equality
  - Diversity: differences between background and experiences
    - Race, gender, and race
    - Political belief, orientation, etc
    - Benefits of diversity: more creative solutions, cultivate stronger relationships -> better performance of individual, teams, companies, and companies with diverse leadership outperform those without
  - Inclusion: address inequities, support diverse perspectives, integrate everyone's contributions
- Bias
  - Implicit bias
    - Shaped through media, environment, culture, people around us, and our lives
    - Subconscious attitudes and stereotypes
    - Everyone has implicit biases
  - Microaggressions
    - Brief and common-place statements that are hostile towards some groups

    - Seemingly small statements that reinforce stereotypes
- Stereotype threat
  - People worrying about confirming stereotype
  - Increases anxiety and self-doubt
- Effective teams
  - Dependability
  - Structure & clarity
  - Meaning (work is fulfilling)
  - Impact (team members feel their work matters)
  - **Psychological Safety** (team members feel free to take risks and express themselves)
- Allyship
  - Taking actions to support individuals from underrepresented groups

Week 5 Video 1: Module 6 Case Study Introduction

- Learning goals
  - Describe the engineering design stages that can be informed by sustainability
  - Explain the challenges related to providing drinking water in Canada
  - Describe the overall objective of the Module 6 case study
- Case study
  - Application for funding for a water treatment system for a fictitious small, remote community in BC
  - Written proposal (Expression of Interest, EOI)
  - Formal presentation
  - Costs committed in the early stages affect actual costs in the later stages
    - Sustainability should be considered from the very beginning
  - Module 6: focus on study and clarify problem, generate and identity solution
    - Stage 0,1,2,3
  - Module 7: develop and test solution (water treatment system)
    - Stage 4
- Same Drinking Water XPrize
  - Goal: to provide access to safe drinking water to everyone, all the time
  - Including developed nations (for example, Flint Michigan)
- Water stress
  - Lack of quantity/quality of water
- Boil water advisory: boil water, do not drink directly (due to concern with water treatment)
  - Issued when safety of water cannot be guaranteed
  - Small communities tend to get more boil water advisory (~80% for communities with <500 ppl)
  - Disproportionate water advisories for first nations communities
- Challenges for small & remote systems
  - Difficult to supply chemicals and parts

    - Challenging to retaining skilled operators
    - Source water quality is often lower
    - Economies of scale (costs more per volume to treat water in small systems)

Week 5 Video 2: Water Treatment Systems

- Learning goals
    - Explain what is meant by "centralized", "semi-decentralized", and "decentralized" water treatment systems
    - List the advantages and disadvantages of each system
    - Describe the centralized and decentralized solutions for the Module 6 case study
- Centralized Water Treatment Systems
    - Found in large cities
    - Single large water treatment plant provides water for large number of people
    - Waste water is brought to one place and treated at waste-water treatment plants
    - Advantages
        - Easier to maintain
        - Easier to monitor treatment process
        - Lower cost/volume of water treated
    - Disadvantages
        - Large infrastructure required
        - Vancouver: 1500km of water pipe, 3000km of sewer pipe
        - Difficult to adjust capacity (not well suited for growth)
- Semi-decentralized
    - Larger number of treatment plants
    - Treatment is still centralized locally
- Decentralized
    - Water treatment at each building (point of entry system)
    - Each business/household (point of use system)
- Module 6
    - Centralized: treated elsewhere
        - Water is treated, and then transported using boat (in bulk or smaller containers)
    - Decentralized/semi decentralized: treated on island
        - Semi decentralized
            - Single source/treatment facility for entire community
        - Decentralized
            - Treatment at each water use facility (i.e. household)

Van Anda Interview notes

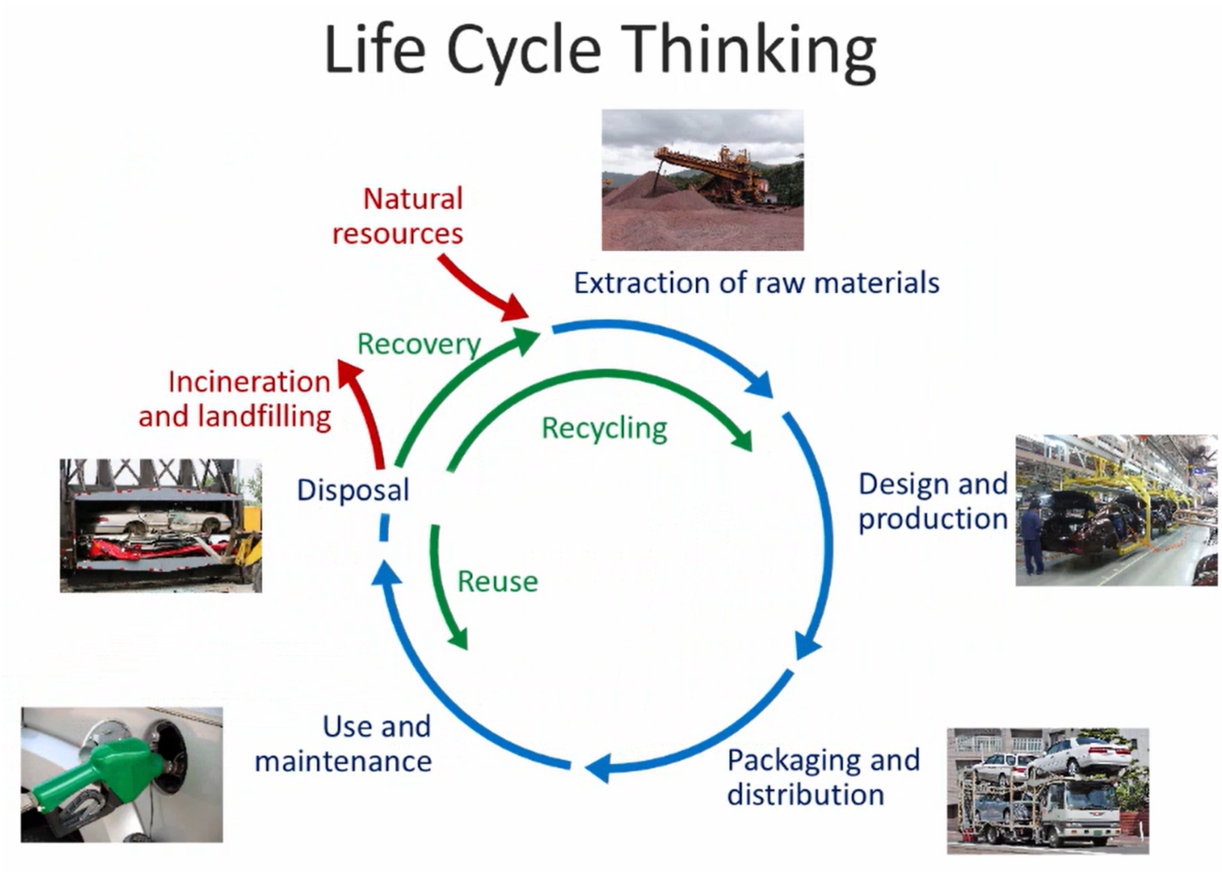
- 2015: small community Van Anda
- First year that they've worried about it

- Climate change
    - Flooding (has not happened in 50+ years)
    - Drought (3 months of no rainfall)
        - Lake gone down 5 feet (evaporation)
- Dry summers, lake level dropped
    - Always had enough water
    - Now: making community aware of water usage
- Water
    - Ferries from Vancouver, or flown in (for high cost)
- No alternate source
    - If the lake is compromised, no options
    - Plan B: trucking in water, not much of a plan
- Lack of alternate source
    - Only piped to one lake
    - Limited number of lakes
- Chlorine
    - $16000 for chlorine
    - Would be best if there was another way not using chlorine
- More willingness to talk about water
- Difficult to talk to representatives of industry
    - Notion that: industry is more important than environment
- Front end load
    - Expensive upfront, minimal cost later on
    - Bad to hit with costs constantly
- Water
    - Drinkable
    - Simple, easy to run
- Putting in a well
    - Because of old mine shafts, not clean water
    - There's cost too (100k to just explore for water)
- Catch water
    - Not enough
- Small systems tend to not be engineered properly
- If money is spent, we want a good system that will last
- Some people are living off the grid, a system that needs power would be an issue to some people

Week 6 Video 1: Life Cycle

- Learning goals
    - List the key goals of assessing for sustainability

- Describe the main concepts considered in Life Cycle Thinking and list the associated Life Cycle stages
    - Describe how Life Cycle Thinking and Systems Thinking relate to assessing for sustainbility
- Sustainability: wellbeing of environment, society, economy
    - Not about tradeoffs between the dimensions
- Life cycle thinking



- Systems thinking
    - Considers how product interacts with other elements in a system
- Sustainability is a property of a system
    - Focus on creating positive contributions, not mitigating adverse effects

Week 6 Video 2: LCA & SLCA

- Learning goals
    - Explain how to conduct both Life Cycle Assessments (LCA) and Streamlined Life Cycle Assessments (SLCA)
    - Describe the advantages and disadvantages of LCAs and SLCAs, and where each might be used in the design process
    - Define the terms "functional unit" and "environmentally responsible product rating"
- LCA
    - Used by many companies in industry
    - Rigorous and structure process

    - ISO 46 pages, 26 requirements
    - Stages
        - Goal definition and scope
            - System boundary: aspects of product and lifecycle stages that are considered
            - Look at material and energy input/output
            - Functional unit: measure of performance for use as a reference unit
        - Inventory analysis
            - Detailed process of identifying material and energy input/output of system boundary
        - Impact assessment
            - Use environmental impact metrics
        - Interpretation
            - Distill impacts
    - Challenges
        - Detailed knowledge is required
        - Impacts must be quantified
        - Focus is primarily on environmental impacts
    - Typically only available late in the design process, when all decisions have been made
- SLCA
    - Qualitatively assess criteria
    - Tabulate in SLCA matrix
    - Sum to determine rating
    - Benefits
        - Simple, fast, and inexpensive
        - Qualitative (more suitable for difficult to quantify criteria)
        - Suitable for use early in design process
        - Captures 80% of environmental issues identified by full LCA

Week 7 Video 1: Appropriate Technology

- Learning goals
    - Explain the concept of appropriate technology
    - List common features of appropriate technology
    - Explain the importance of the community when considering appropriate technology
- Appropriate technology
    - Design solution considers the key stakeholders across all life cycle stages for that solution
    - Solution is appropriate for the context
- Example: clean water in Africa
    - Play pump: intended for children to use by spinning. tens of millions funded
    - In reality: novelty wears off and children sit on it.
    - Sometimes it is too cold/hot for operating the play pump
    - The tech is difficult to maintain by locals

    - Grown women end up using the play pump, which is not appropriately sized for the actual users
    - Lack of consultation with communities and users
    - Upon closer inspection, the play pump does not address the context of the problem. It is not appropriate technology
- Attributes of appropriate technology
    - Suitable for the social and economic context of the region in which it is to be applied
    - It is environmentally sound
    - Locally accepted and adapted
- Build relationship & trust with the community from the beginning. Listen to and empathize with the community. Involve them in the design process.

Week 8 Video 1: Business Letters

- Learning Goals
    - Describe how to format a formal business letter
    - Describe how the 7Cs relate to business letter writing
    - Use appropriate tone and language for a formal business letter
- Formal
    - Consider audience, purpose, context
    - Attention to 7Cs
- Layout
    - 1" to 1-1/4" margins
    - Block format (all text at left margin)
    - Body (left aligned)
    - Font size 11/12 pt
- Elements
    - Sender's address
    - Date
    - Receiver's address (include title)
    - Salutation (Dear [xyz]:)
    - Body (not indented)
        - Intro paragraph (greeting + purpose)
        - Supporting details
        - Concluding paragraph (restate purpose/request action)
    - Closing (sincerely, thank you, best regards, etc.)
    - Blank lines for signature
    - Name and title (if applicable)
- Variations
    - Letterhead (omit writing address). Only used on the first page
    - Long title for recipient: placed on new line
    - Bolded reference: critical information
    - Enclosures: additional information

- cc: carbon copy/complimentary copy

Week 8 Video 2: Satisfaction Curves

- Learning goals
  - Describe the difference between requirements, evaluation criteria, attributes, and design parameters
  - Explain how attributes relate to satisfaction
  - Describe the general shape of common satisfaction curves
- Needs: wants and wishes
- Target design specifications: requirements
- Evaluation criteria: how well a solution addresses the needs

Week 9 Video 1

- Flow physics
  - Describe the relationship between pressure and depth in a fluid
  - Describe the relationship between pressure difference and fluid flow
  - Use the relationships between flow rate, flow velocity, depth, and pressure to express relevant quantities for a discharging tank
- Hydrostatic pressure
  - At surface: $p = p_{atm} = 0$ (reference pressure)
  - At depth h: $p = \rho g h$ $[\mathrm{N/m^2} = \mathrm{Pa}]$
- Discharge tank
  - $Q_{out} = A_{nozzle}\sqrt{2gh}$
  - $Q_{out} = A_{nozzle}\sqrt{\frac{2p}{\rho}}$. p: pressure at outlet
  - $v_{out} = \frac{Q_{out}}{A_{nozzle}} = \sqrt{2gh} = \sqrt{\frac{2p}{\rho}}$
    - Only depends on height h
  - Pressure as a function of velocity: $p = \frac{\rho v_{out}^2}{2}$
- Flow goes from higher pressure to lower pressure

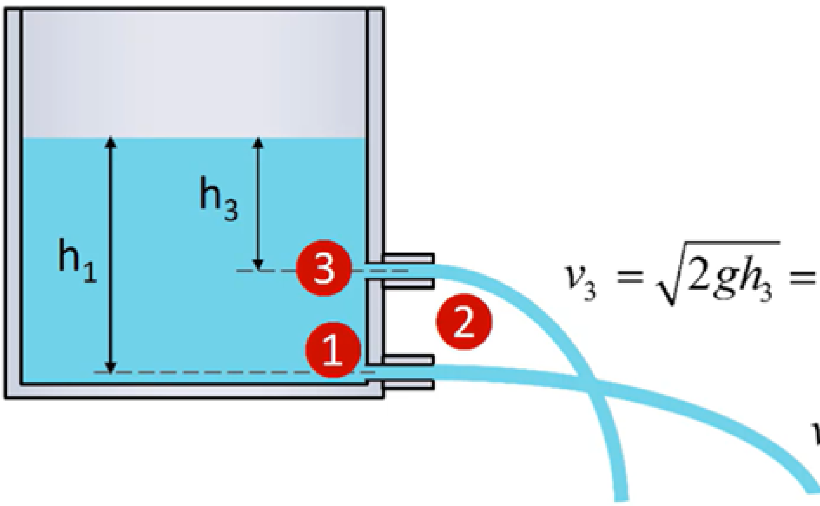
Week 9 Video 2: RWH modelling

- Learning goals
  - Describe the relationship between catchment area, rainfall, and flowrate into the storage tank
  - Describe how to use a spreadsheet to model water collection in the rainwater harvesting system
- Rainwater harvesting system – simulated in excel spreadsheet

Week 10 Video 1: Flow Physics and the RWH

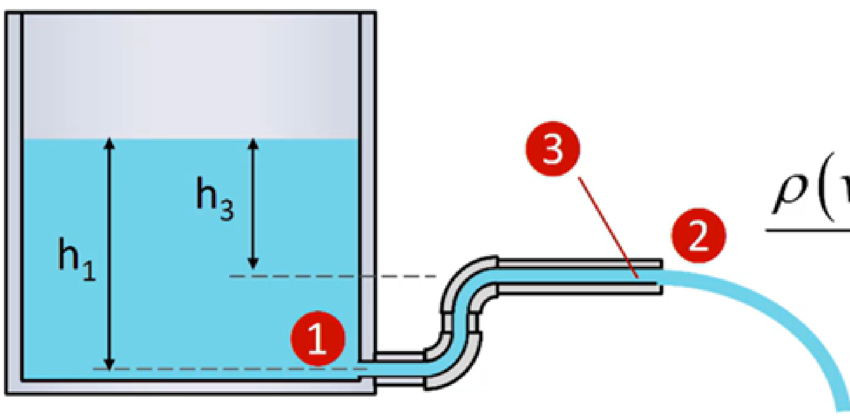
- Describe the relationship between flow rate, flow velocity, and pressure for a discharging tank

- Describe the effect that piping losses, flow restrictions, and elevation changes have on pressure in a piping system



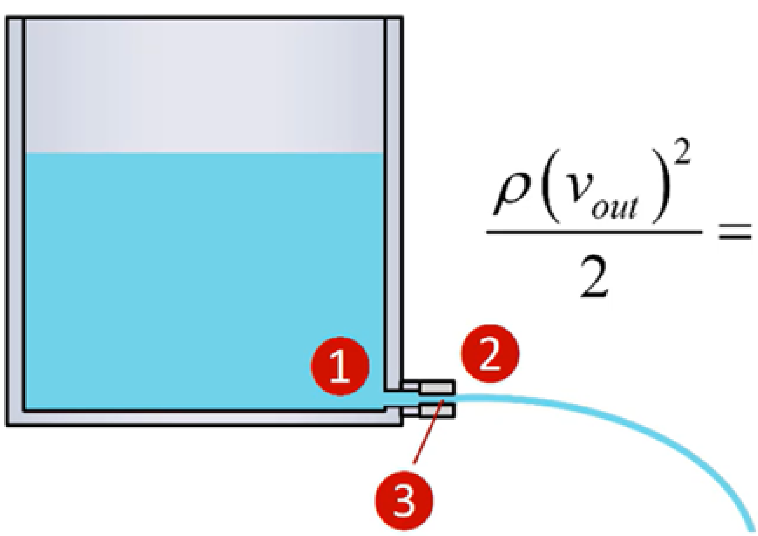
$$v_3 = \sqrt{2gh_3} = \sqrt{\frac{2p_3}{\rho}}$$

$$v_1 = \sqrt{2gh_1} = \sqrt{\frac{2p_1}{\rho}}$$



$$\frac{\rho\left(v_{out}\right)^2}{2} = p_3 - p_2$$

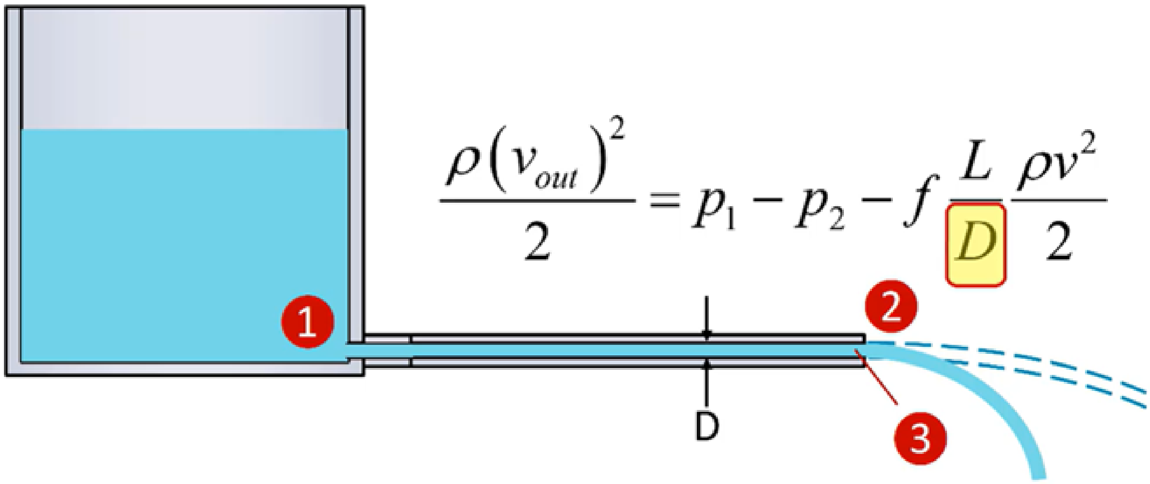
<u>Losses through restrictions</u>



$$\frac{\rho\left(v_{out}\right)^2}{2} = p_1 - p_2 - K\frac{\rho {v_3}^2}{2}$$

- $p_{loss} = K\frac{\rho v^2}{2}$ (K is a loss coefficient tabulated for common components)

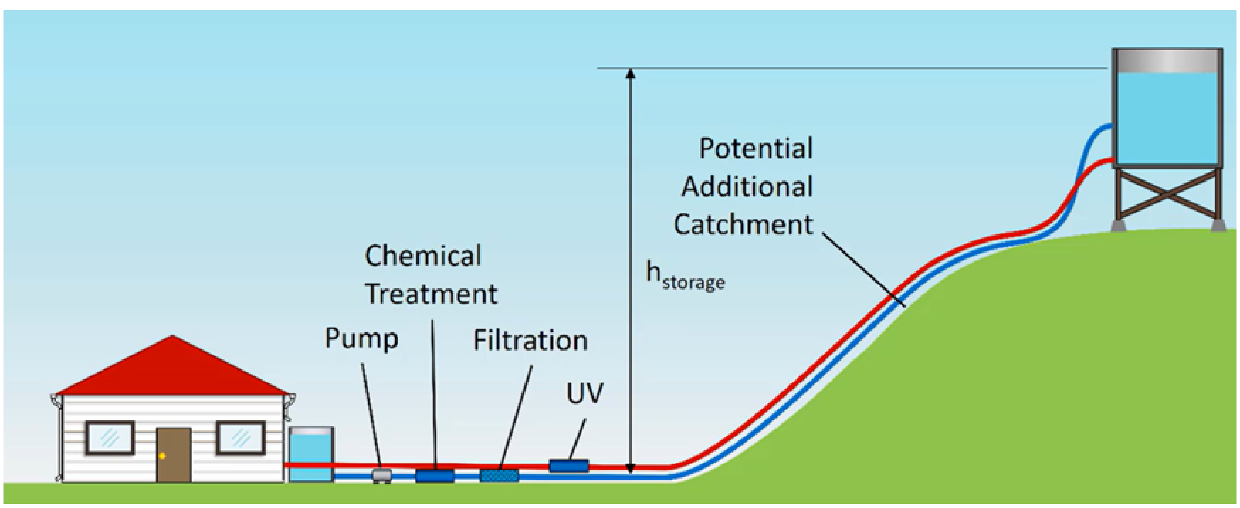
Losses through pipes

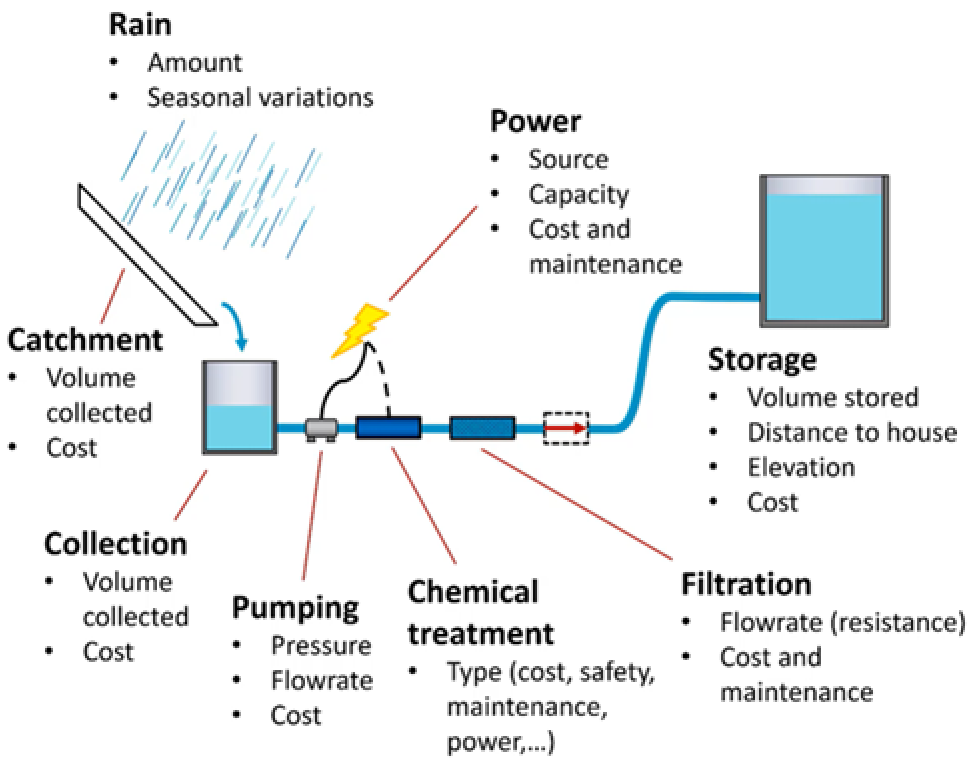


- $p_{loss} = f\frac{L}{D}\frac{\rho v^2}{2}$
  - f: friction factor
  - D: diameter
  - L: length of the pipe (longer pipe = more losses)

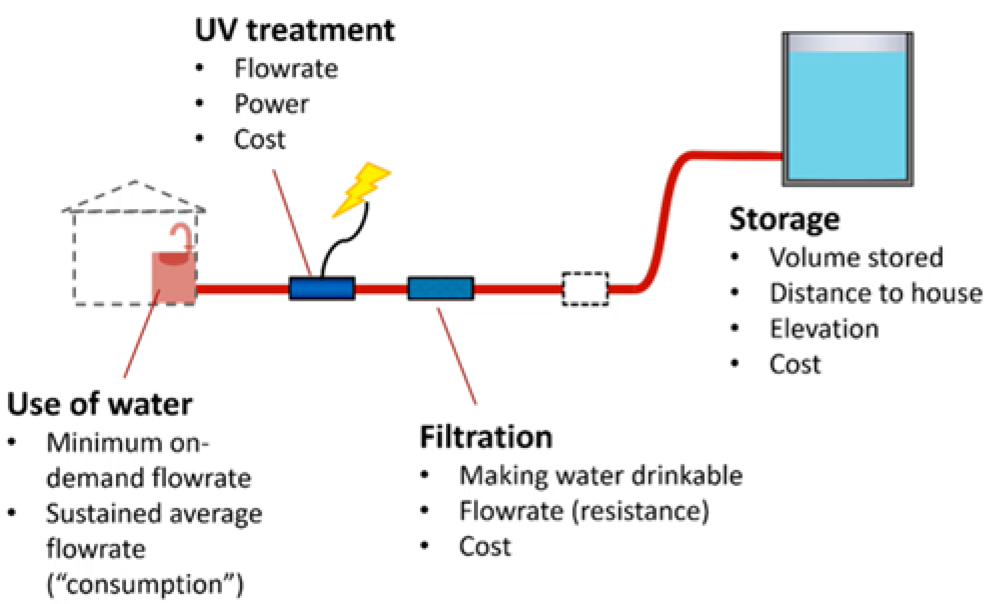
Week 10 Video 2: RWH Implementation

- Learning goals
  - Describe the arrangement and role of components in the rainwater harvesting system
  - Explain how flowrate depends on the selection and sizing of the pump, filtration, and piping, and on the location of the storage tank
- Storage system

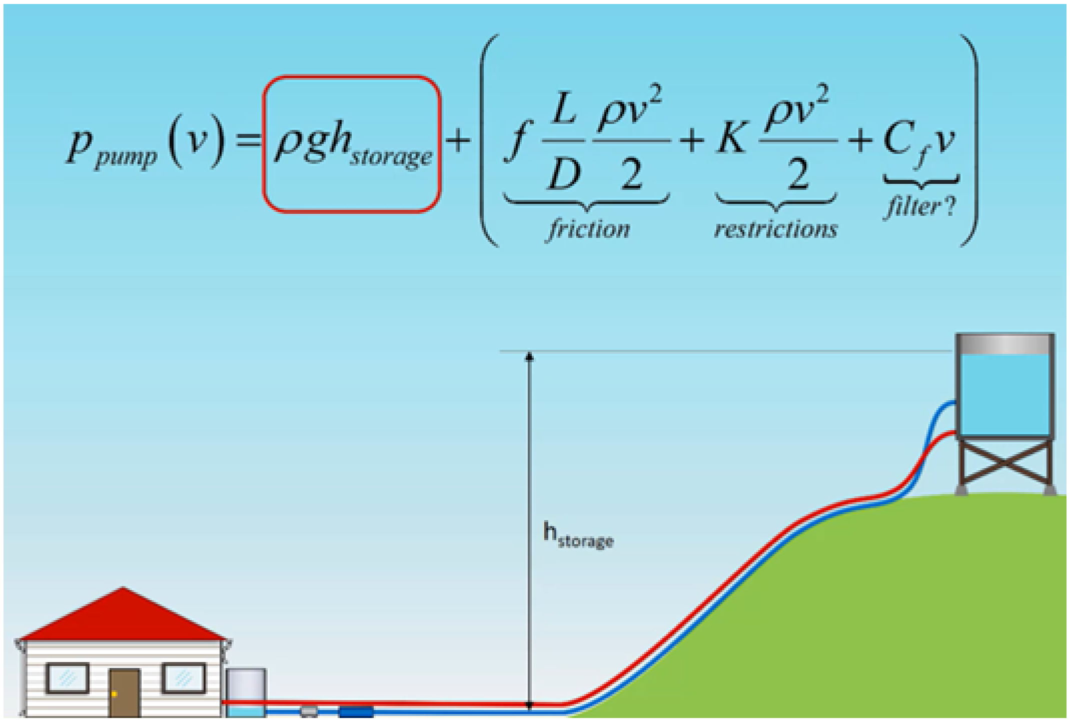


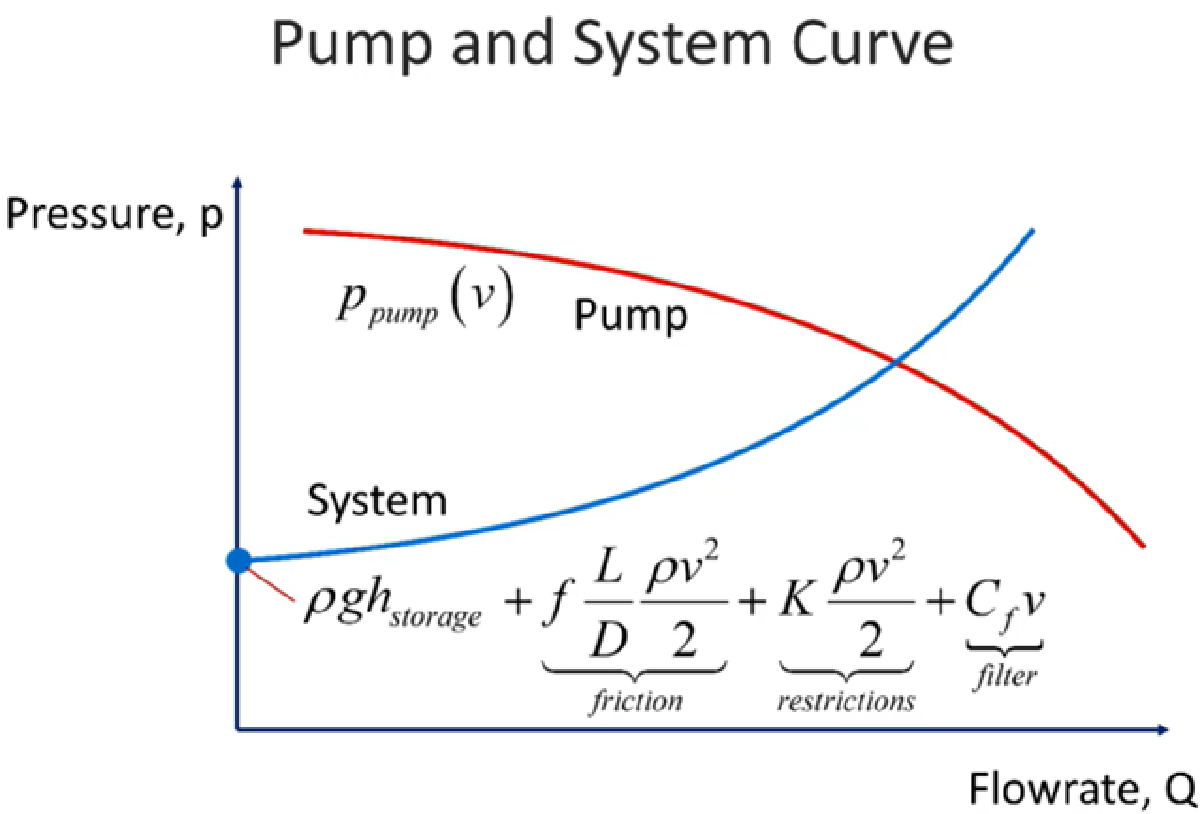


- Supply system



- Storage system details





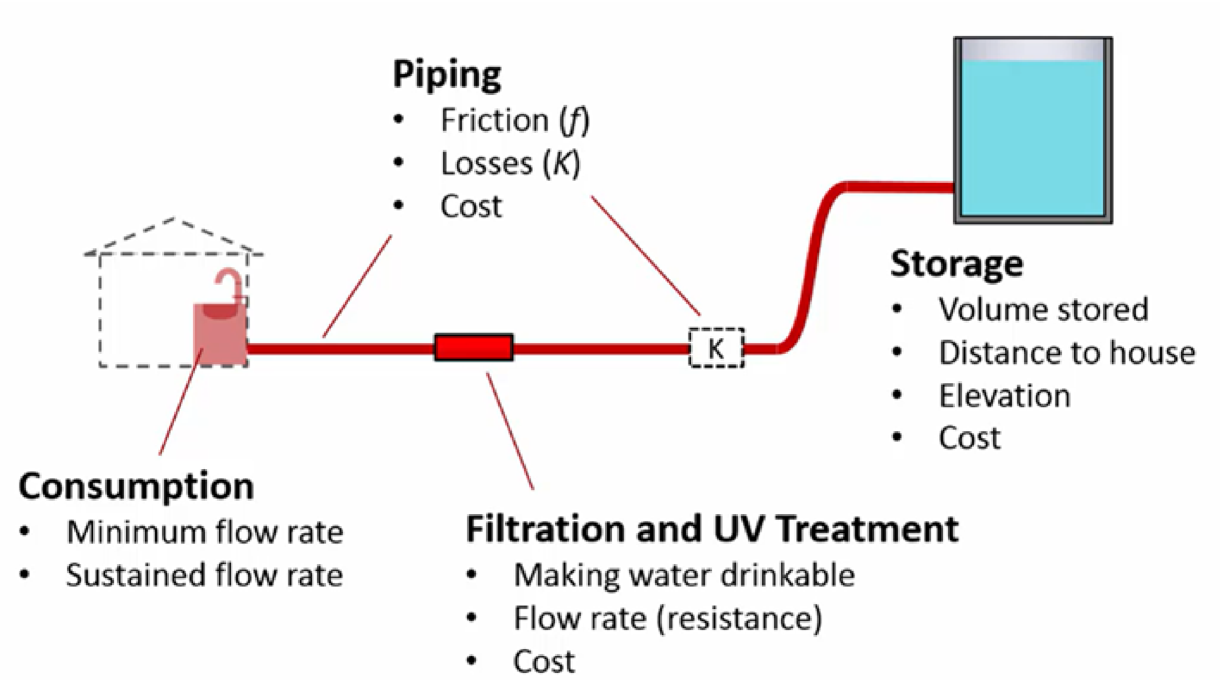
Week 11 Video 1: Curve Fitting

- Learning Goals
    - Describe how to fit a function to a set of data in Excel
    - Describe what the coefficient of determination is, explain how it is used, and compute it for a curve fit in Excel
- Curve fitting in Excel: create scatter plot, add trendline
    - Set type of fit (linear, polynomial, power, etc.)

- Set y-intercept
- Show trendline equation
- Show R^2 value

- Coefficient of determination R^2
  - Indicates "goodness of fit"
  - $0 \leq R^2 \leq 1$
  - $R^2 = 0$: no correlation
  - $R^2 = 1$: perfect correlation
- Increasing the polynomial order will increase R^2 because there are more parameters that can be adjusted

Week 11 Video 2: RWH System Integration



- Learning goals
  - Describe the arrangement and role of the filter components in the rainwater harvesting system
  - Explain how the satisfaction curves are used and combined to determine overall system satisfaction
  - Describe how a spreadsheet can be used to develop a numerical model of the rainwater harvester water consumption line subsystem
- Filtration and UV treatment
  - UV and 1 micron filter (mandatory)
  - 5 micron and 200 micron filter (optional)
  - Overall C_f value is the sum of individual C_f values for each filter

Filter Modules	Filter Size	Present?	Cf [Pa/(m/s)]	Actual Filter Life [L]	Filter Life Data [L] No pre-filter	5 µm pre	200 µm pre
	1 µm filter	y	10000	20000	5000	20000	15000
	5 µm filter	y	4000	20000	10000		20000
	200 µm filter	y	800	20000	20000		
	Total		14800				

Filter Modules	Filter Size	Present?	Cf [Pa/(m/s)]	Actual Filter Life [L]	Filter Life Data [L] No pre-filter	5 µm pre	200 µm pre
	1 µm filter	y	10000	20000	5000	20000	15000
	5 µm filter	y	4000	20000	10000		20000
	200 µm filter	y	800	20000	20000		
	Total		14800				

Attributes			Weights	Satisfaction		
Q_D	32.9	L/min	15%	$S(Q_D)$	100	%
M	11	#/year	15%	S(M)	100	%
C	625	L/day	20%	S(C)	63	%
				Total	42.5	%

Day	Total Volume Through Filter [L] 1 µm filter	5 µm filter	200 µm filter	Maintenance for Filter Change 1 µm filter	5 µm filter	200 µm filter	Day with operation
1	625	625	625				
31	19375	19375	19375				
32	20000	20000	20000				
33	625	625	625	1	1	1	1
34	1250	1250	1250				
35	1875	1875	1875				

- Maintenance
  - Filters are replaced the day before the exceed maximum life
  - Multiple filters replaced on the same day counts as one operation
- Consumption
  - We set our target consumption in L/day
  - If consumption is not met, we assume occupants pay to ship in water that day
- Overall satisfaction
  - Weighted sum of individual satisfactions (similar to WDM)