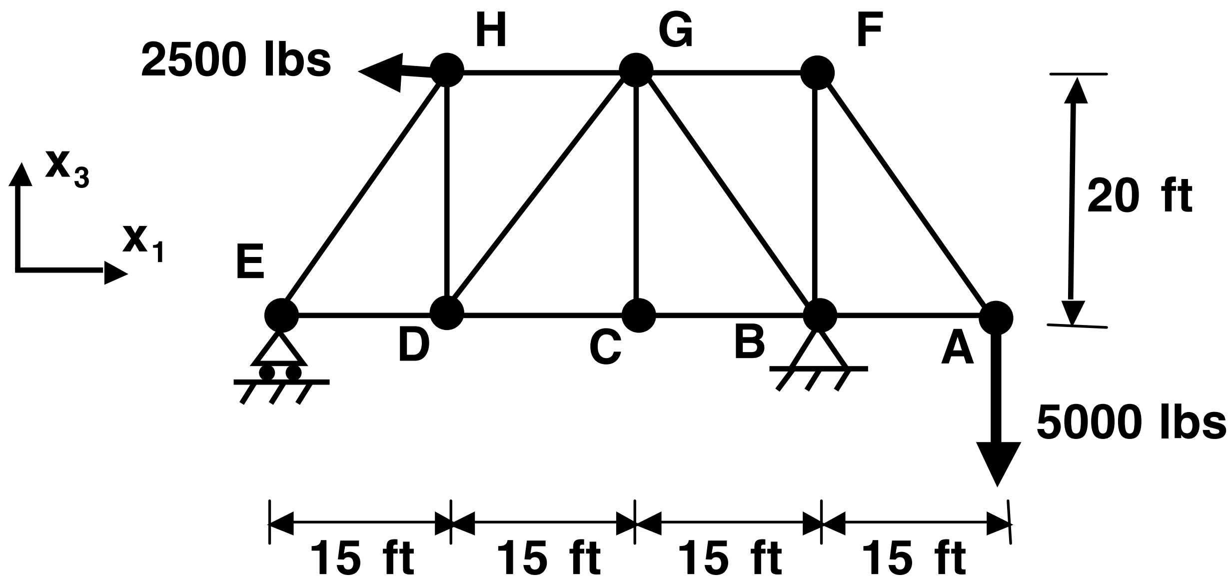
Unified Engineering Problem Set 5 Lectures: M7, M8, M9 ***(w/look-ahead)***
Week 6 Fall, 2008 Units: (M1.3), M1.4 ***(w/ look-ahead)***

M6 (M6.1) ***(20 M-points)*** A 20-foot high truss has a 60-foot span and is made up of thirteen individual bars of various lengths in four bays as shown in the accompanying illustration. Each bay of the truss is 15 feet long. The truss is simply-supported being attached via a roller support at the left end, and a pin support 45 feet from that roller at the junction of the third and fourth bays. Loads are applied at two joints as shown.



(a) Draw the free body diagram for this situation.

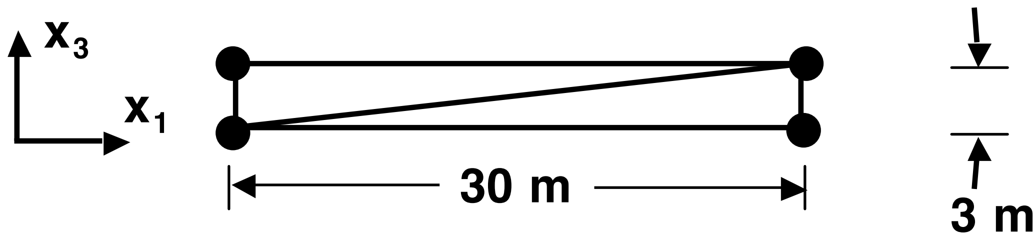
(b) Determine the reaction forces.

(c) Without performing any calculations, can you determine if there are any bars in the truss that carry no load? Which are they? Explain clearly.

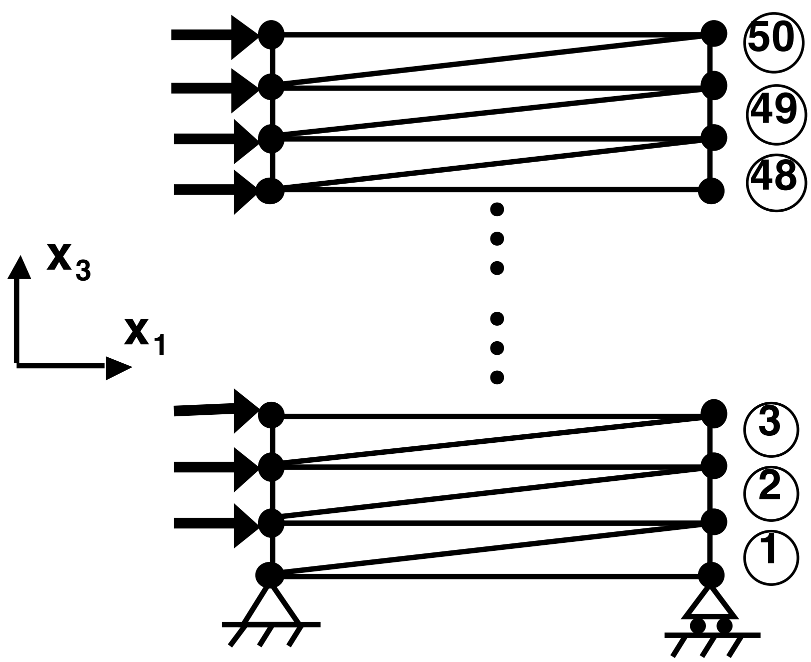
(d) Determine the load in all the bars using the the *method of joints*. Draw a clear diagram showing the entire configuration and the manner in which loads are carried.

(e) Check the result for the load in bars within the third bay (bars CB, GB, GF) by the *method of sections*.

M7 **(M6.2)** ***(10 M-points)*** A European engineering firm has been hired to model the Prudential Center for horizontal loads applied to the building. In their first-level model, they choose to model the building as a two-dimensional truss comprising identical bays for each of the 50 floors of the building, each 30 meters in length and 3 meters in height. The structural configuration of the bay unit model is shown below.



For evaluation purposes, horizontal loading due to considerations of wind and other items are represented as concentrated loads of 2500 N at the upwind node at the intersection of each floor above the ground. The structure is modeled as being simply-supported in the ground. This overall configuration can be partially represented as shown.



(a) Draw the general Free Body Diagram for this overall structural model.

(b) Determine the reaction forces for this overall structural configuration.

(c) Determine the bar loads in the bars modeling the bay representing the 25th floor (not including the horizontal bars).

Problem F6

Consider a 2D unsteady, incompressible flow with pathlines that obey,

$$x = 1 + t$$
$$y = 1 - t^2$$

(a) Find an expression for the velocity vector.
(b) Draw arrows for the velocity vector in the range x = [0,2] and y = [0,2] at t = -1, 0, and +1.
(c) Sketch 3 different pathlines in the range x = [0,2] and y = [0,2].
(d) Sketch one streamline in the range x = [0,2] and y = [0,2] at t = -1, 0, and +1.
(e) Is flow continuity satisfied? Explain.

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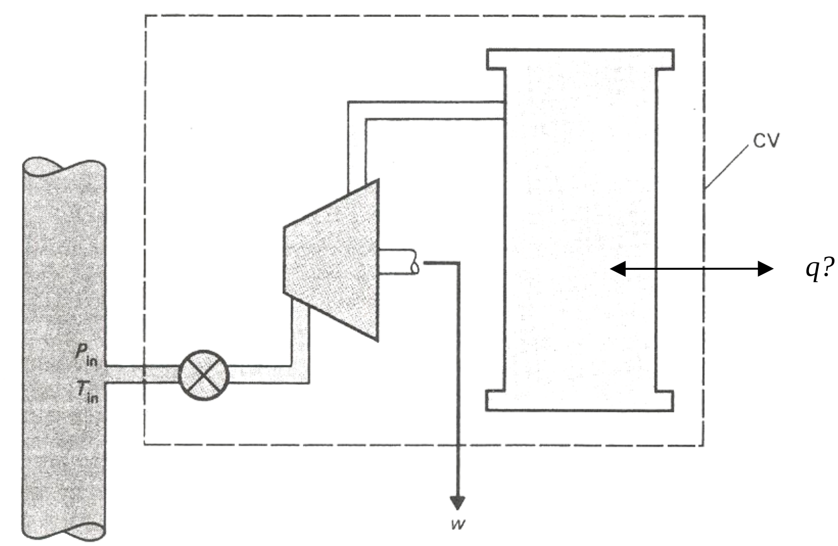
(Add a short summary of the concepts you are using to solve the problem)

Problem T8

A nitrogen supply line provides nitrogen at any required rate at a temperature of 300°C and a pressure of 10 atm (see figure). At a given time t_1, a valve is opened from the nitrogen line, and nitrogen flows through an ideal turbine into an initially evacuated tank. When the pressure in the tank just reaches the supply line pressure, the temperature of the nitrogen in the tank is measured to be 250°C. The valve is then closed. The specific shaft work output of the turbine during this process is measured to be 45.0 kJ/kg.

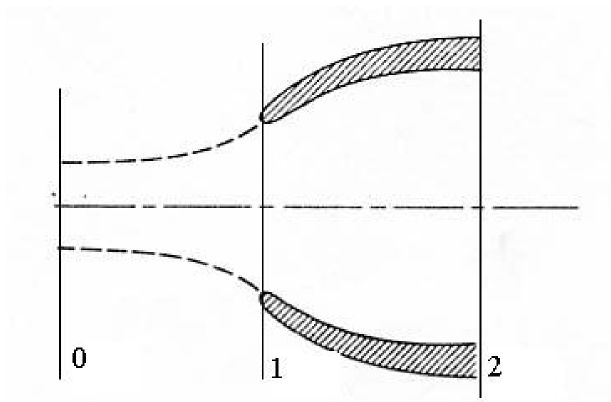
Is there heat transfer *q* to or from the control volume shown? If so, find the heat transfer per kilogram of nitrogen during this process (kJ/kg). Assume for nitrogen gas a molar mass of 28 g/mol and ratio of specific heats of 1.4.



(Add a short summary of the concepts you are using to solve the problem)

Problem T9

A jet engine in an aircraft flying at M = 0.8 ingests an airflow of 100 kg/s through an inlet area of 3.07 m² (station 1). The Mach number of the flow entering the fan at station 2 is 0.4. The ambient temperature and pressure are 222 K and 9.57 kPa, respectively. You can assume air to be an ideal gas with $\gamma = 1.4$ and $R = 287$ J/kg-K.



a) What are the stagnation pressure and the stagnation temperature at inlet, station 1?

b) What are the static pressure and static temperature at the fan face, station 2?

c) Find the Mach number at inlet station 1.

Hint: express the mass flow as a function of stagnation pressure, stagnation temperature, Mach number, flow area, ratio of specific heats γ, and gas constant R. Then, define the non-dimensional mass flow, so called corrected mass flow, as a function of Mach number only, f(M$_1$), and solve graphically or numerically for the Mach number:

$$\frac{\dot{m}\sqrt{T_{t_1}}}{p_{t_1} A_1}\sqrt{\frac{R}{\gamma}} = f(M_1) \rightarrow \textit{find} \quad M_1$$

d) What is the static pressure ratio across the internal diffuser, station 1 to station 2, p_1/p_2?

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(Add a short summary of the concepts you are using to solve the problem)

Problem T10

Two Carnot engines operate in series between two reservoirs maintained at 600K and 300K, respectively, as shown below. The energy rejected by the first engine is input into the second engine. If the first engine's efficiency is 20 percent greater than the second engine's efficiency, what is the intermediate temperature T_i?