Name: _____

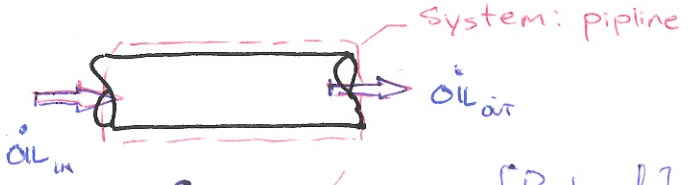
CM: _____

ROSE-HULMAN Institute of Technology
Sophomore Engineering Curriculum

ES201 Conservation & Accounting Principles

Example

1) The mass flow rate of crude oil at the entrance of the Alaskan Pipeline is measured to be 76.4 lbm/min. There are no leaks, no other entrances, or chemical reactions taking place in the pipeline. There is only one outlet. What is the mass flow rate at the outlet?



Prop: oil (mass)
Time: rate (ongoing)

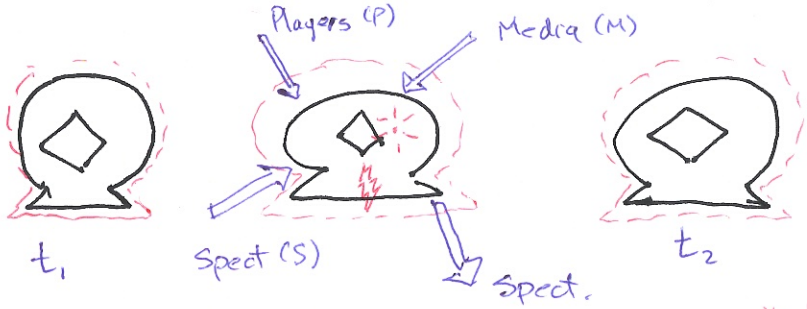
$$\left[\begin{matrix}\text{Rate of}\\ \text{accumulation}\end{matrix}\right] = \left[\begin{matrix}\text{Rate of}\\ \text{oil}\\ \text{in}\end{matrix}\right] - \left[\begin{matrix}\text{Rate of}\\ \text{oil}\\ \text{out}\end{matrix}\right] + \left[\begin{matrix}\text{Rate of}\\ \text{OIL}\\ \text{generated}\end{matrix}\right] - \left[\begin{matrix}\text{Rate of}\\ \text{OIL}\\ \text{CONSUMED}\end{matrix}\right]$$

(accumulation → 0; generated → 0; consumed → 0)

$$0 = \dot{OIL}_{IN} - \dot{OIL}_{OUT}$$

$$\dot{OIL}_{OUT} = \dot{OIL}_{IN} = \boxed{76.4 \text{ lbm/min}}$$

2) A baseball stadium can hold a maximum of 55,000 spectators. Before the gates open for a game, there are 200 stadium personnel in the stadium. When the gates open, players, spectators and media all enter the stadium. Fifty (50) baseball players enter the stadium, and 500 times more spectators than media enter the stadium. During the game, ¼ of the spectators leave. There are 30,000 spectators at the end of the game. No players, stadium personnel or media leave. Use a conservation and accounting framework to calculate the total number of people in the stadium at the end of the game.



System: stadium
Prop: people
Time: finite time

No births
No deaths

$$B(t_2) - B(t_1) = B_{IN} - B_{OUT} + B_{gen} - B_{CON} \qquad (1)$$

Accum of B over t_1 to t_2

B entering / leaving @ system boundary

B GEN / CONS. inside system

Look @ players first.

$B(t_2) = P(t_2)$ $\quad P_{IN} = 50$

$B(t_1) = P(t_1)$ → 0

(1) becomes

$$P_2 - P_1 = P_{IN} - P_{OUT}$$

($P_1 \to 0$, $P_{OUT} \to 0$)

$$P_2 = P_{IN} \qquad P_{IN} = 50.$$

$$\boxed{P_2 = 50}$$

Next look @ personell:

$$B_2 = W_2 \qquad W_{IN} = 0$$
$$B_1 = W_1 \qquad W_{OUT} = 0$$

$$W_2 - W_1 = W_{IN} - W_{OUT}$$

($W_{IN} \to 0$, $W_{OUT} \to 0$)

$$W_2 - 200 = 0 \qquad \boxed{W_2 = 200}$$

Spectators:

$$S_2 - S_1 = S_{IN} - S_{OUT}$$

($S_1 \to 0$)

$$S_2 = 30{,}000 \qquad S_{IN} = 500 \cdot M_{IN}$$
$$S_{OUT} = S_{IN}/4$$

$$30{,}000 - 0 = 500\,M_{IN} - S_{IN}/4$$

$$30{,}000 = 500\,M_{IN} - \frac{500\,M_{IN}}{4} \implies M_{IN} = 80$$

Media:

$$M_2 - M_1 = M_{IN} - M_{OUT}$$

($M_1 \to 0$, $M_{OUT} \to 0$)

$$M_2 = M_{IN}$$

$$\boxed{M_2 = 80}$$

$$\therefore B_2 = P_2 + W_2 + S_2 + M_2$$
$$= 50 + 200 + 30{,}000 + 80$$
$$= \boxed{30{,}330} \leftarrow \text{ANS}$$