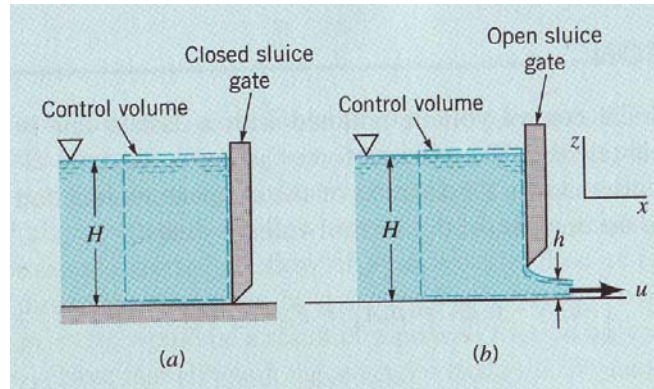


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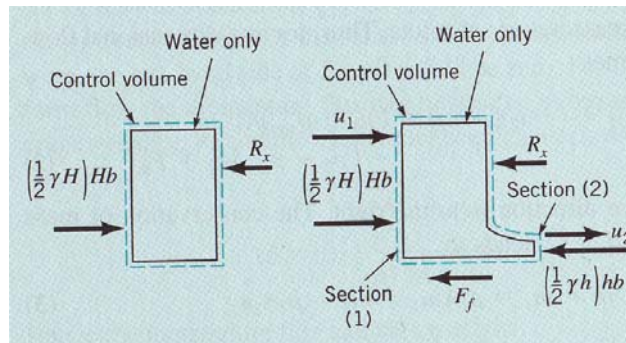
Quiz: No. 3  
 Course: 58:160, Fall 2009

Time: 15 minutes

A sluice gate across a channel of width  $b$  is shown in the closed and open position. Find the forces  $R_x$  required to hold the gate in place for both positions. Which one needs larger force? Assume that friction forces are negligible.



**Solutions:**



$$\sum F_x = \dot{m}_{out}V_{out} - \dot{m}_{in}V_{in}$$

**Closed position:**

$$V_{out} = V_{in} = 0$$

$$\sum F_x = \text{pressure force} - R_{closed} - \underbrace{\text{friction force}}_{F_f=0; \text{negligible}}$$

$$\text{pressure force} = F_p = \gamma h_c A = \gamma 0.5 H H b = 1/2 \gamma H^2 b$$

$$\Rightarrow 1/2 \gamma H^2 b - R_{closed} = 0 \Rightarrow R_{closed} = 1/2 \gamma H^2 b$$

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Open position:

$$\sum F_x = \dot{m}_{out} V_{out} - \dot{m}_{in} V_{in}$$

$$\dot{m}_{out} = \rho A_{out} V_{out} = \rho h b u$$

$$\dot{m}_{in} = \dot{m}_{out} \Rightarrow \rho A_{out} V_{out} = \rho A_{in} V_{in} \Rightarrow V_{in} = A_{out} V_{out} / A_{in} = h u / H$$

$$\sum F_x = \text{pressure forces} - R_{closed} - \underbrace{\text{friction force}}_{F_f=0; \text{negligible}}$$

$$\text{pressure forces} = F_{p_{in}} - F_{p_{out}} = 1/2 \gamma H^2 b - 1/2 \gamma h^2 b$$

$$\Rightarrow 1/2 \gamma H^2 b - 1/2 \gamma h^2 b - R_{open} = \rho h b u (u - h u / H) \Rightarrow R_{open} = 1/2 \gamma H^2 b - 1/2 \gamma h^2 b - \rho h b u^2 \left(1 - \frac{h}{H}\right)$$

Therefore:

$$R_{open} < R_{closed}$$