

## Model/Approach: Energy Density Model

**Finish 6.1.3** (~15 min)

**Act-6.1.4 Wrap-up of DLM 10 FNTs 1 - 7** (~ 60 min)

**Learning Goals:**

- Get a firmer grasp on the meaning and behavior of the various fluid parameters in various kinds of flow phenomena.
- Get a firmer grasp on how to use the energy density model to analyze fluid phenomena without flow.
- Get a firmer grasp on how to use the energy density model to analyze fluid phenomena with flow.

**AC-6.1.5 Analyzing A Fluid Circuit** (~ 20 min)

**Learning Goals**

- Gain experience analyzing the fluid **circuit**.
- Gain further experience working with the extended energy density model (including dissipation and energy sources/pumps)

## Announcements

- **Reading Assignment** - Read Unit 6 through page 78.

## Wrap-up of DLM 10 FNTs 1 - 7

### In Your Small Group

#### FNTs 2 and 3 (10 mins.)

Compare your responses to these two FNTs with other members of your small group. If you have any remaining questions, put only these questions on the board.

#### Quick whole class discussion

#### FNTs 1, 4, and 5 (25 mins.)

Your DL instructor will tell you which one of these FNTs to put on the board. Quickly compare your response to the assigned FNT with other group members and put it on the board.

#### Quick whole class discussion

#### FNT 6 (5 mins.)

Discuss your responses to this FNT in your small group. Nothing to put on board.

How does the sudden enlargement of the artery affect the pressure of the blood at that point, and how does that change in pressure then affect the enlarged artery?

When blood flows from the arteries into the capillaries, it goes from one large "tube" to several much smaller ones. It is well known that the blood slows down when it reaches the capillaries (a good thing, since the slower rate improves the oxygen and CO<sub>2</sub> exchange between the blood and the tissues surrounding the capillaries). According to our energy density model, fluids *speed up* when the tube is narrowed. How then can we explain why blood *slows down* when it enters the capillaries? The explanation here does not have anything to do with dissipation.

#### Quick whole class discussion

#### FNT 7 (20 mins.)

In order to apply the energy density model to a pair of points, those points must be contained in a fluid system that is continuous and "doing the same thing" all along the fluid.

- 1) Identify the **four** separate fluid systems in this physical situation.
- 2) In which fluid system(s) can we assume gravitational potential energy density changes are negligible?
- 3) In which fluid system(s) can we assume **all** energy density changes are negligible? How does this simplify the analysis of this physical situation? That is, which fluid system(s) must we actually apply the transport equation to?

Sketch the horizontal pipe and u-tube on the board, and label the **two pairs** of points that you need to apply the energy density model to, in order to determine the difference in height of water in the u-tube.

**Write on the board** only the appropriate form of the equation expressing energy conservation for each of the **two pairs** of points. Include subscripts in your equations. Be prepared to explain how the terms in your equation are correlated with the points in your sketch. Don't put all your algebra and numerical answers on the board.

Compare your numerical answers with others in your group and correct any mistakes you made. Don't put numerical answers on the board.

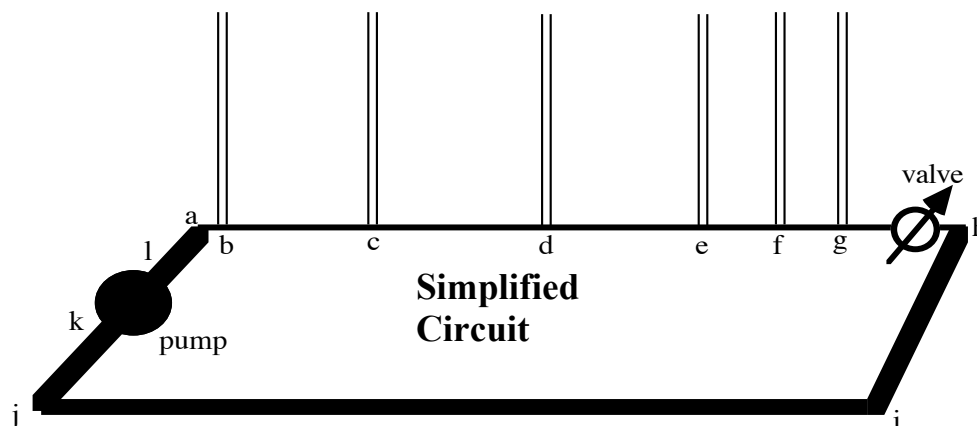
### Whole Class Discussion

## Analyzing A Fluid Circuit

**Understanding the Physical Circuit.** Your first job is to see how the collection of plastic pipes, buckets, pump, etc. is equivalent to a fluid circuit constructed entirely **in a horizontal plane** (except for the pressure measuring tubes) with a pump that keeps an almost constant pressure between points *a* and *h* in the diagram. The diagram below is a **schematic diagram of the actual circuit**. It is a **simplified circuit**, showing the parts we are interested in. It is **not the actual circuit**. The simplified circuit will allow us to understand the various pressures around the real circuit, especially at those points where the pressure is determined by the height of the water columns.

### Notes on the Simplified Circuit shown in the schematic:

In the Simplified Circuit, large diameter tubes (shown by the wide dark line) run from *h* to *i* to *j* to *k* through the pump, and from *l* to *a*. There is no dissipation as the fluid flows in this section of the simplified circuit. There is dissipation in the section of the simplified circuit from point *a* to point *g* and in the valve. The pump keeps a constant pressure difference between points *a* and *h*. All of the simplified circuit through which the water moves is in the same horizontal plane.



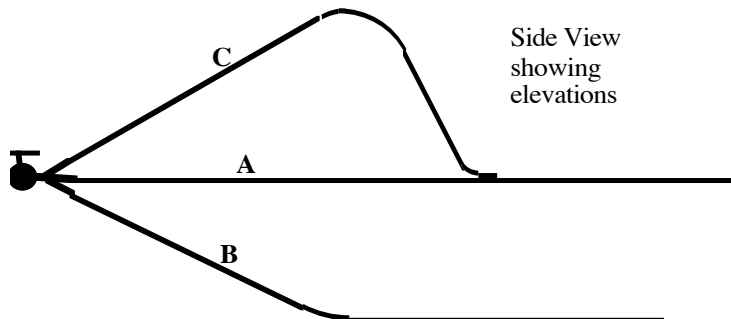
Before you can explain why the system works the way it does, you will need to carefully observe the real system. Your DL Instructor will show you how to operate the system, and you can go back and “play” with it as necessary as you work on your explanations.

- A) Compare the real physical circuit to the simplified circuit shown in the schematic diagram.
- 1) Which parts of the real apparatus correspond to “the pump” in the simplified circuit?
  - 2) Which parts of the real apparatus correspond to the section of the simplified circuit between *a* and *h*?
  - 3) Which parts of the real apparatus correspond to the “zero resistance” part of the simplified circuit?
  - 4) Which energy density systems change in the real apparatus between the points that correspond to the simplified circuit points *a* and *h*?
  - 5) What is the purpose of the vertical tubes in both the simplified circuit and in the physical circuit?
  - 6) What fluid quantity is directly affected by changing the valve setting in both circuits?
- B) Develop a group explanation for why the simplified circuit is a useful way to understand the behavior of the physical circuit.
- C) Analyze the behavior you directly observe in the physical circuit, in terms of the simplified circuit:
- 1) Does the pressure-change from *a* to *h* depend on the valve setting? Or is it always the same?
  - 2) Does the pressure difference between adjacent vertical tubes change as the valve setting is changed?
  - 3) What does your answer to (2) tell you about the change in other energy systems?

**FNTs:** Use the fluid transport equation (fully extended Bernoulli equation) to logically respond to these FNT prompts. These FNTs were used previously as quiz questions; you should by now be able to apply the energy density model, using the fluid transport equation, to respond to the prompts.

**FNT 1.**

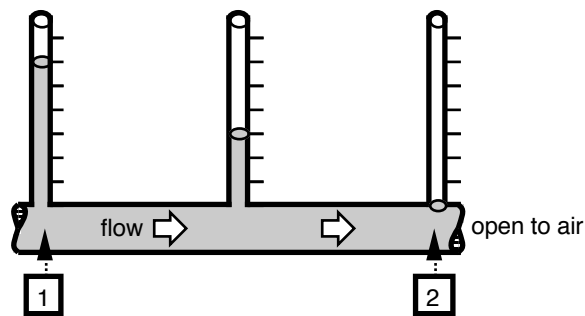
Three **identical** garden hoses (same length and same inner diameter) are attached to the same faucet through a three-way divider, which supplies water at the same pressure to all three hoses. All three hoses are open to the atmosphere at their other ends. Hose *A* runs along a level path at the elevation of the faucet. Hose *B* runs down a hill and its free end is some 10 ft below the level of the faucet. Hose *C* runs up and over a high wall, but its free end is back at the elevation of the faucet. How do the flow rates through the three hoses compare? Justify your answer using the physics we have studied this quarter. Make certain to explicitly show the pair of points you are applying the model between, and this should be your *first* step in solving these problems.



**FNT 2**

Water flows through a horizontal pipe similar to the pipe in DL. It enters the pipe at point (1), then leaves the pipe at point (2), which is open to the atmosphere. The height of the water in each vertical column is shown at right.

Now suppose that the length of this pipe is doubled. The pressure at point (1) is the same as before. Point (2) is still open to the atmosphere. Water is again allowed to flow from point (1) to point (2).



- (a) We find the flow rate in the longer pipe is smaller than the flow rate in the shorter pipe. Explain why this happens. By what factor would the flow of water through this pipe decrease? Explain your answer and show your reasoning.
- (b) Fill in the water levels in each of the vertical tubes in the pipe whose length has been doubled, in the diagram above. Be clear and accurate in drawing each water level.

