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Flow Measurement

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TECH 3821
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Rotameter

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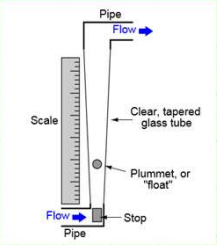
- Variable area flowmeter (aka rotameter)



2

Weir and Flume

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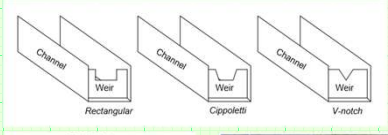
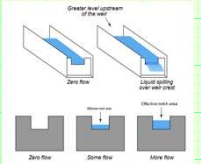
- Variable area flowmeter used to measure flow rate through open channels (like irrigation ditches)





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Pressure Based

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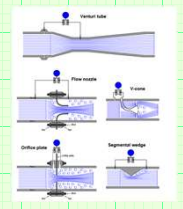

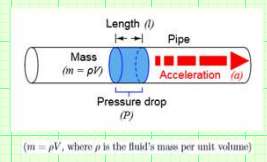

$(m = \rho V$, where ρ is the fluid's mass per unit volume)

Constriction in the pipe causes a linear acceleration. The Pressure Differential is then used to calculate flow.

4

Pressure Based

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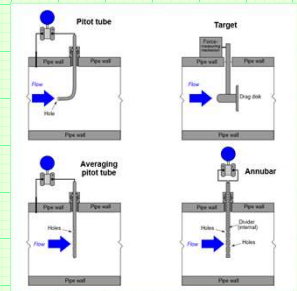
- Another method of pressure based flow measurement is to cause a deceleration (negative acceleration)



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Installation

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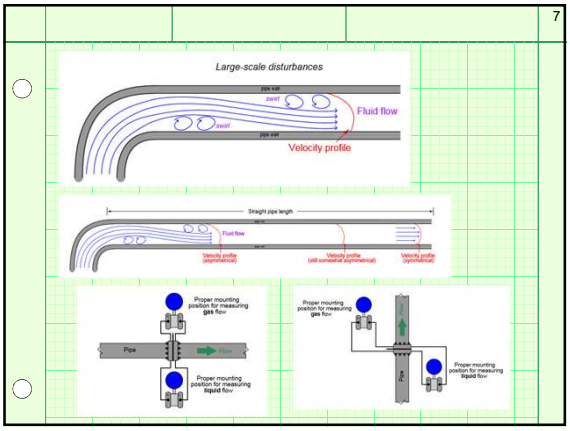
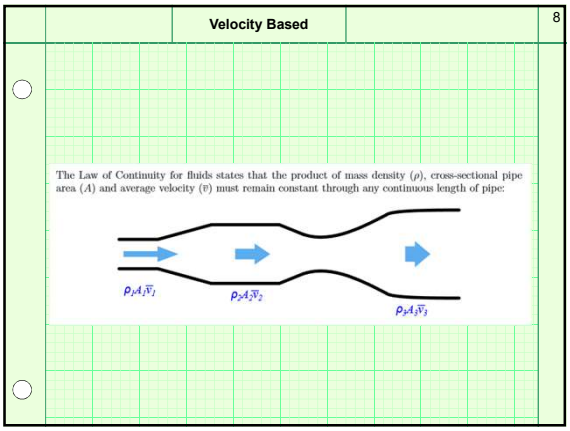
- Proper Installation Consideration
  - Necessary Upstream and downstream straight pipe lengths
  - Beta ratio (ratio of orifice boar diameter to pipe diameter)
  - Impulse tube tap locations
  - Tap Finish
  - Transmitter location in relation to pipe

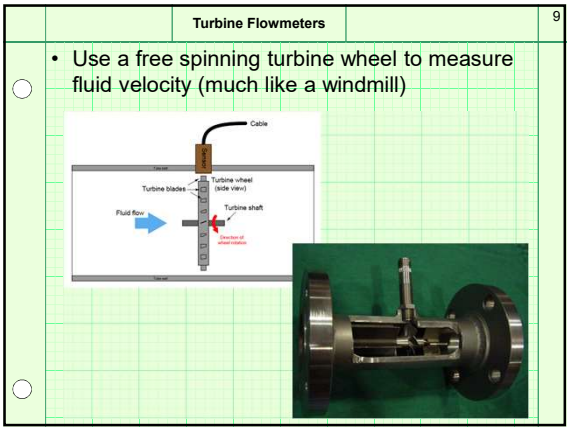
6


7
Large-scale disturbances
Fluid flow
Velocity profile
Straight pipe length
Fluid flow
Velocity profile (asymmetrical)
Velocity profile (slight somewhat asymmetrical)
Velocity profile (symmetrical)
Proper mounting position for measuring gas flow
Pipe
Flow
Proper mounting position for measuring liquid flow
Proper mounting position for measuring gas flow
Pipe
Proper mounting position for measuring liquid flow

7


Velocity Based
8
The Law of Continuity for fluids states that the product of mass density (ρ), cross-sectional pipe area (A) and average velocity ($\bar{v}$) must remain constant through any continuous length of pipe:
$\rho_1 A_1 \bar{v}_1$
$\rho_2 A_2 \bar{v}_2$
$\rho_3 A_3 \bar{v}_3$

8


Turbine Flowmeters
9
• Use a free spinning turbine wheel to measure fluid velocity (much like a windmill)
Cable
Sensor
Turbine wheel (side view)
Turbine blades
Turbine shaft
Fluid flow
Direction of wheel rotation

9

Paddlewheel Flowmeter

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Vortex

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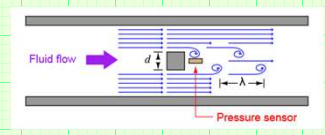
- When a fluid passes a stationary object, there is a tendency for the fluid to form vortices on either side of the object.



- These vortices can be detected using pressure sensors and are relative to the fluid flow

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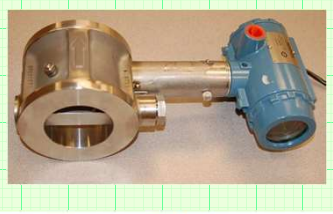
Vortex

12



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Magnetic Flowmeters

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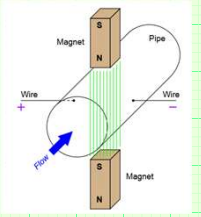
- The direction of liquid flow cuts perpendicularly through the lines of magnetic flux, generating a voltage along an axis perpendicular to both. Metal electrodes opposite each other in the pipe wall intercept this voltage, making it readable to an electronic circuit.



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Mag Flow

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- Considerations
- The liquid must be a reasonably good conductor of electricity
- The pipe must be completely filled with liquid to ensure contact with both probes as well as to ensure flow across the entire cross-section of the pipe
- The flowtube must be properly grounded to avoid errors caused by stray electric currents in the liquid

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Mag Flow

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Ultrasonic

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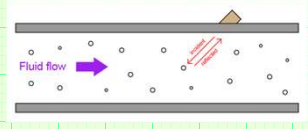
- Ultrasonic flowmeters use the Doppler effect (measuring the frequency shift on the sound to measure velocity)



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Transit Time

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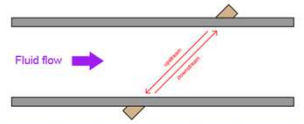
Transit-time flowmeters, sometimes called *counterpropagation* flowmeters, use a pair of opposed sensors to measure the time difference between a sound pulse traveling with the fluid flow versus a sound pulse traveling against the fluid flow. Since the motion of fluid tends to carry a sound wave along, the sound pulse transmitted downstream will make the journey faster than a sound pulse transmitted upstream[6]:



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Optical Flowmeters

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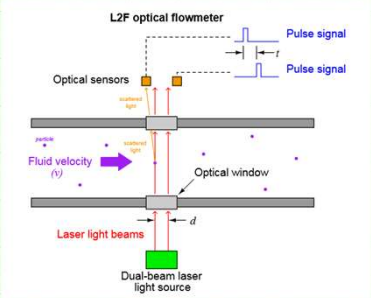

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Positive Displacement

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- Passes a fixed volume of fluid though with every cycle.

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Coriolis Flowmeter

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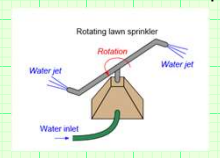
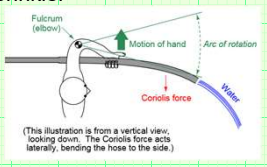
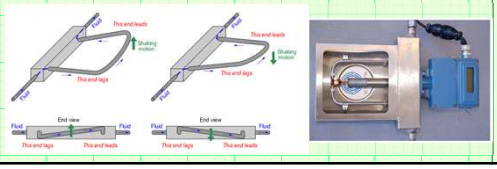
- Works similar to a sprinkler





Practical Coriolis Flowmeter



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Weight feeders

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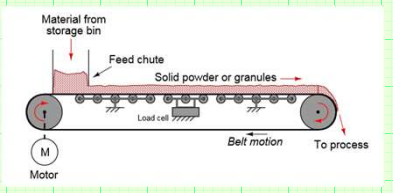

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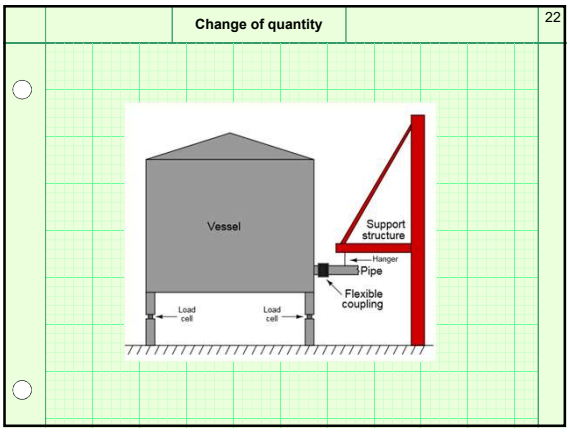
Change of quantity
22
Vessel
Support structure
Hanger
Pipe
Flexible coupling
Load cell
Load cell

22