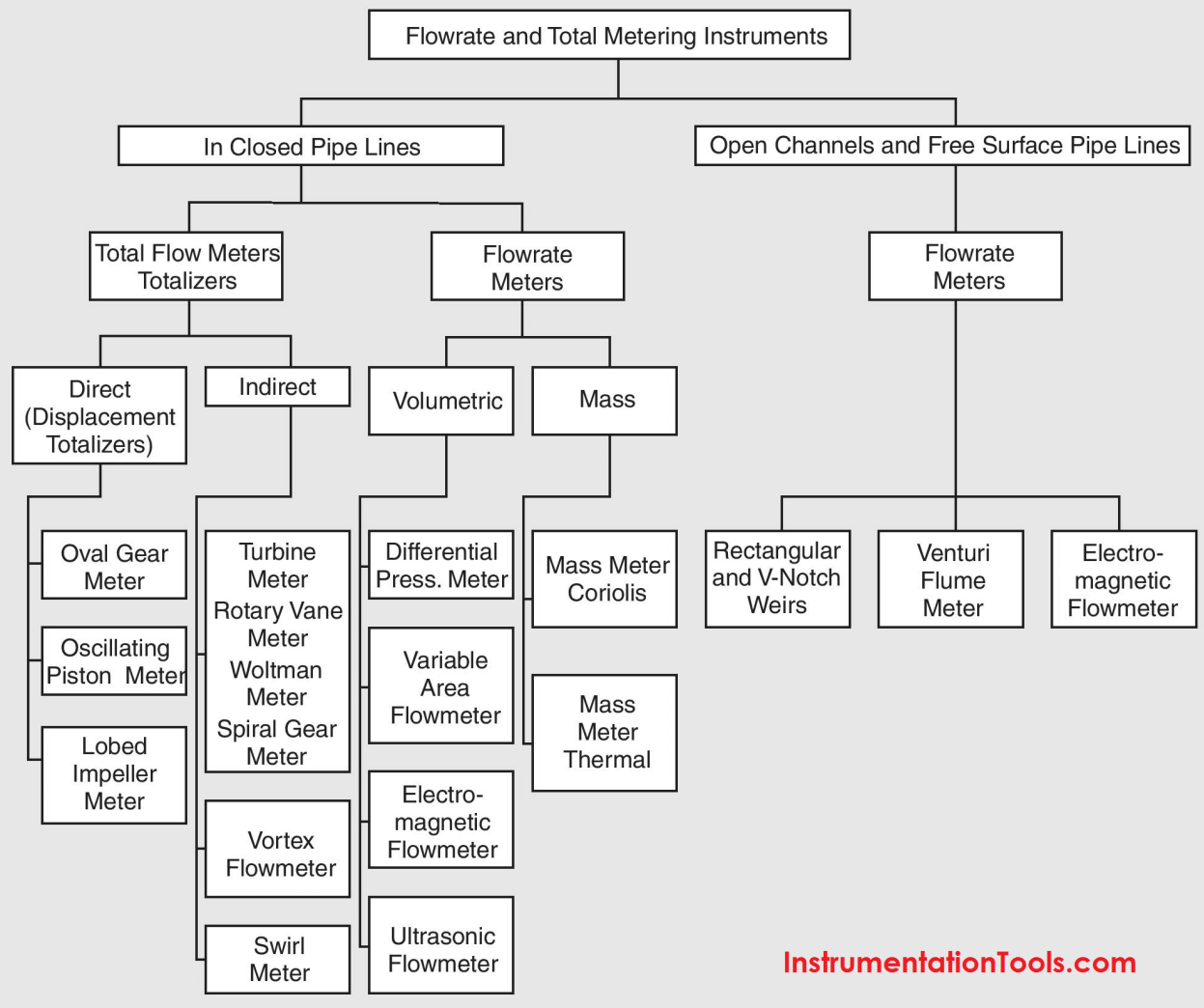
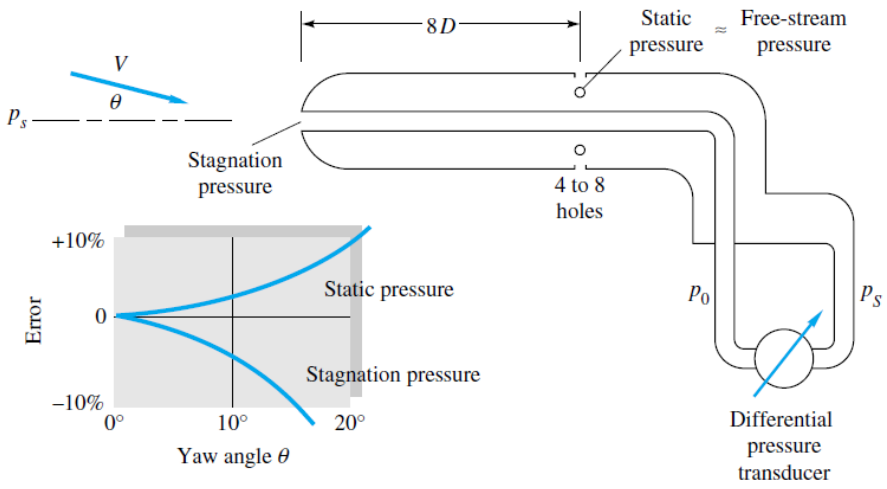
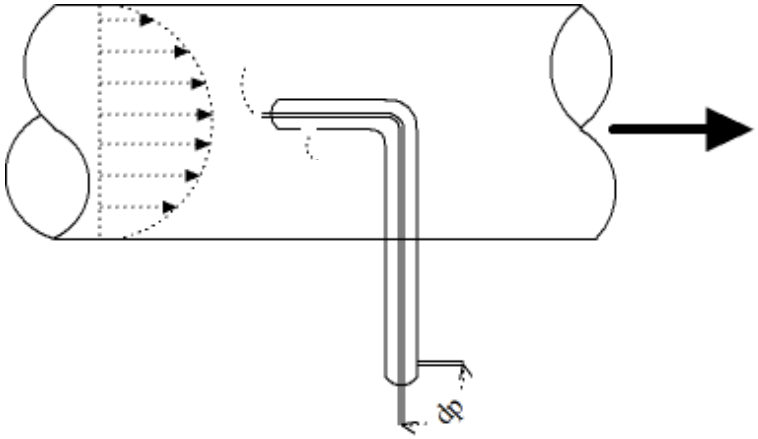
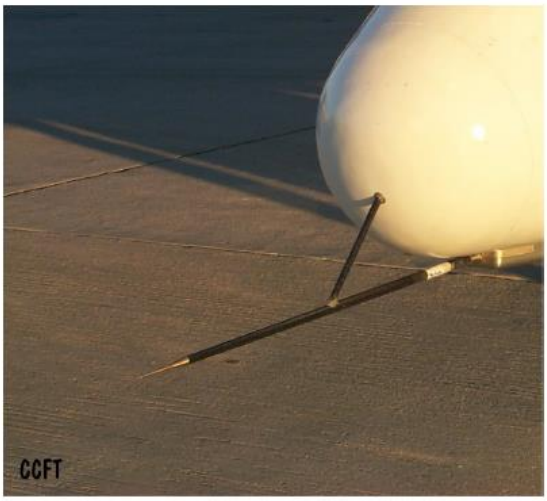

PLEASE
PREPAY
CONTAINS UP TO 5% BIODIESEL
DIESEL
CONTAINS UP TO 10% ETHANOL
TOP TIER
DIESEL
UNLEAD
PLUS
Diesel
87
89
93


Flowrate and Total Metering Instruments
In Closed Pipe Lines
Open Channels and Free Surface Pipe Lines
Total Flow Meters Totalizers
Flowrate Meters
Flowrate Meters
Direct (Displacement Totalizers)
Indirect
Volumetric
Mass
Oval Gear Meter
Oscillating Piston Meter
Lobed Impeller Meter
Turbine Meter
Rotary Vane Meter
Woltman Meter
Spiral Gear Meter
Vortex Flowmeter
Swirl Meter
Differential Press. Meter
Variable Area Flowmeter
Electro-magnetic Flowmeter
Ultrasonic Flowmeter
Mass Meter Coriolis
Mass Meter Thermal
Rectangular and V-Notch Weirs
Venturi Flume Meter
Electro-magnetic Flowmeter
InstrumentationTools.com

Local velocity measurement: Pitot's tube





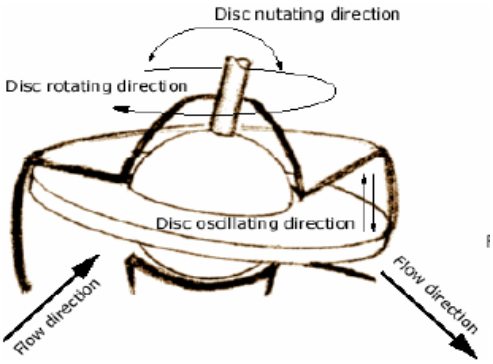


Volume-flow (mass-flow) measurements:

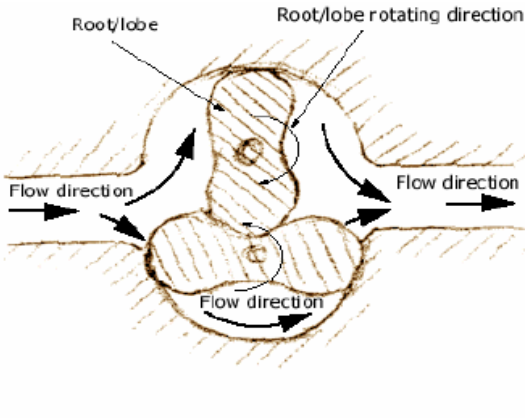
The mechanical instruments measure actual mass or volume of fluid by trapping it and counting it, i.e., *direct measurement.* The various types of measurement are:

1. Mass measurement
    - *a.* Weighing tanks
    - *b.* Tilting traps
2. Volume measurement
    - *a.* Volume tanks
    - *b.* Reciprocating pistons (*Positive displacement flowmeters*)
    - *c.* Rotating slotted rings
    - *d.* Nutating disk
    - *e.* Sliding vanes
    - *f.* Gear or lobed impellers
    - *g.* Reciprocating bellows
    - *h.* Sealed-drum compartments

The last three of these are suitable for gas flow measurement.



Nutating disk



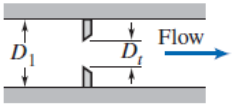
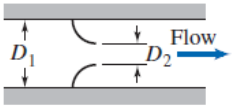
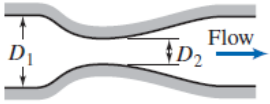
Rotating lobe

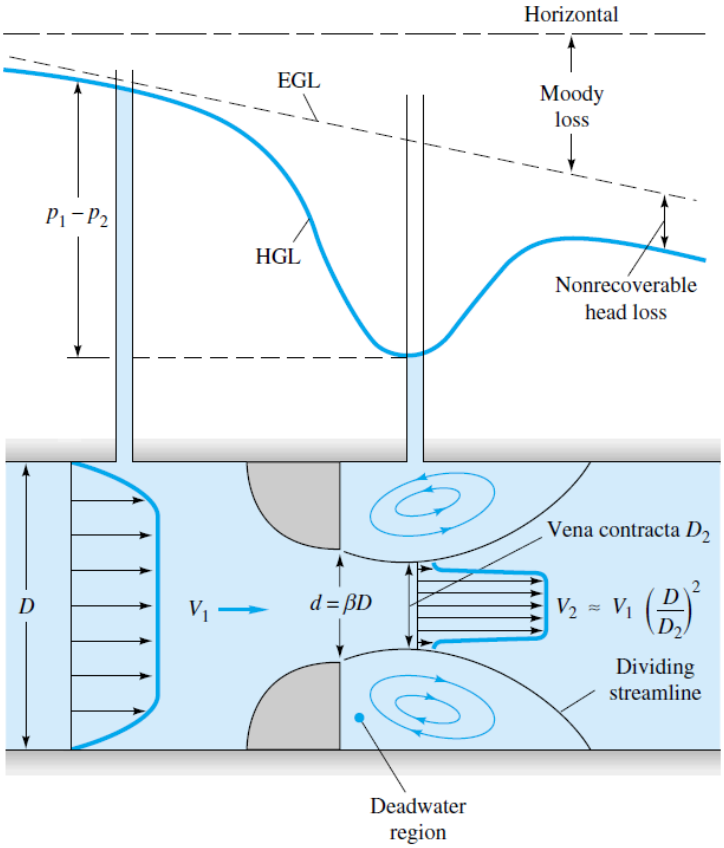
Household water meter

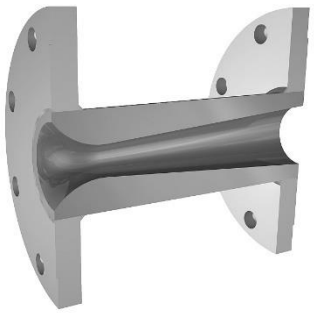
Volume-flow (mass-flow) measurements:

The head-loss devices obstruct the flow and cause a pressure drop which is a measure of flux:

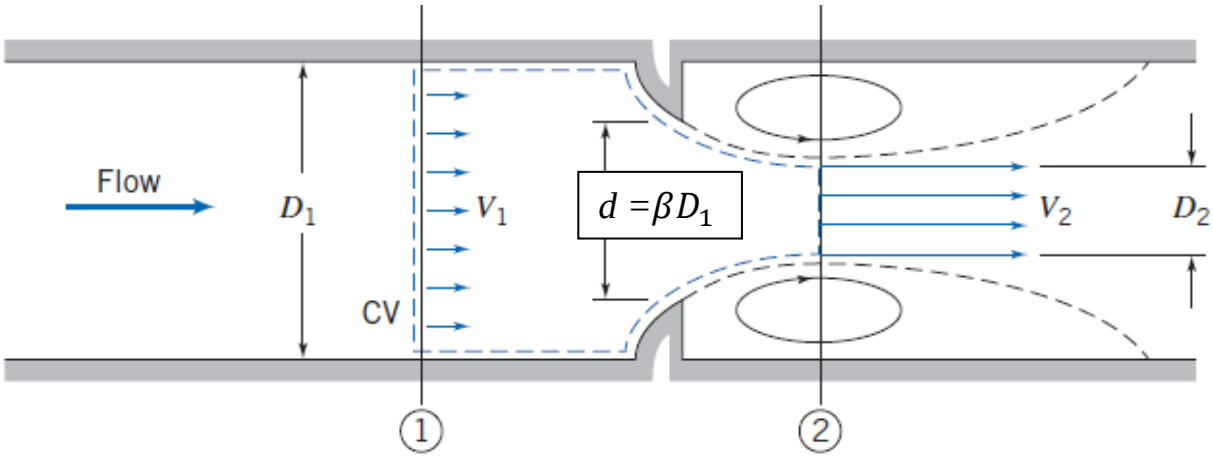
1. Bernoulli-type devices
    a. Thin-plate orifice
    b. Flow nozzle
    c. Venturi tube

Flow Meter Type	Diagram	Head Loss	Initial Cost
Orifice		High	Low
Flow Nozzle		Intermediate	Intermediate
Venturi		Low	High





Principle of operation Bernoulli restriction/obstruction meters:



Standard designs

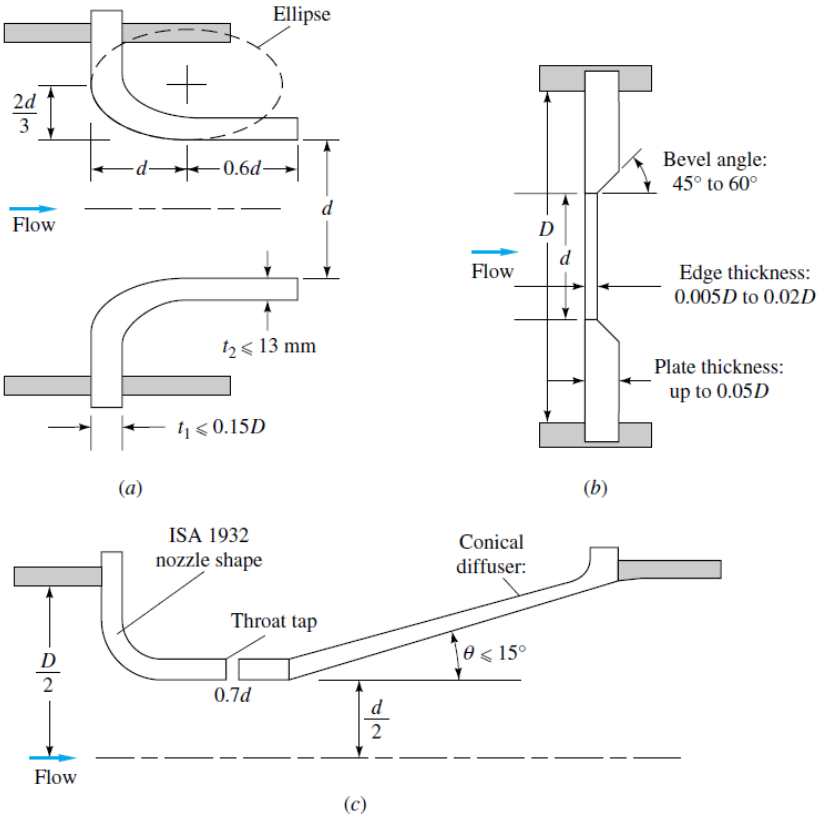
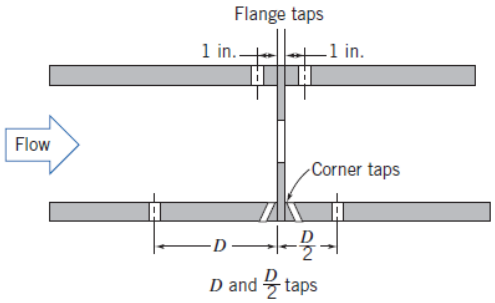


Fig. 6.39 International standard shapes for the three primary Bernoulli obstruction-type meters: (*a*) long radius nozzle; (*b*) thin-plate orifice; (*c*) venturi nozzle.

Correlations for C_D and β :

Concentric orifice:

$$C_D = 0.5959 + 0.0312\beta^{2.1} - 0.184\beta^8 + 91.71\beta^{2.5}Re_D^{-0.75} + \frac{0.09\beta^4}{1-\beta^4}F_1 - 0.0337\beta^3 F_2$$

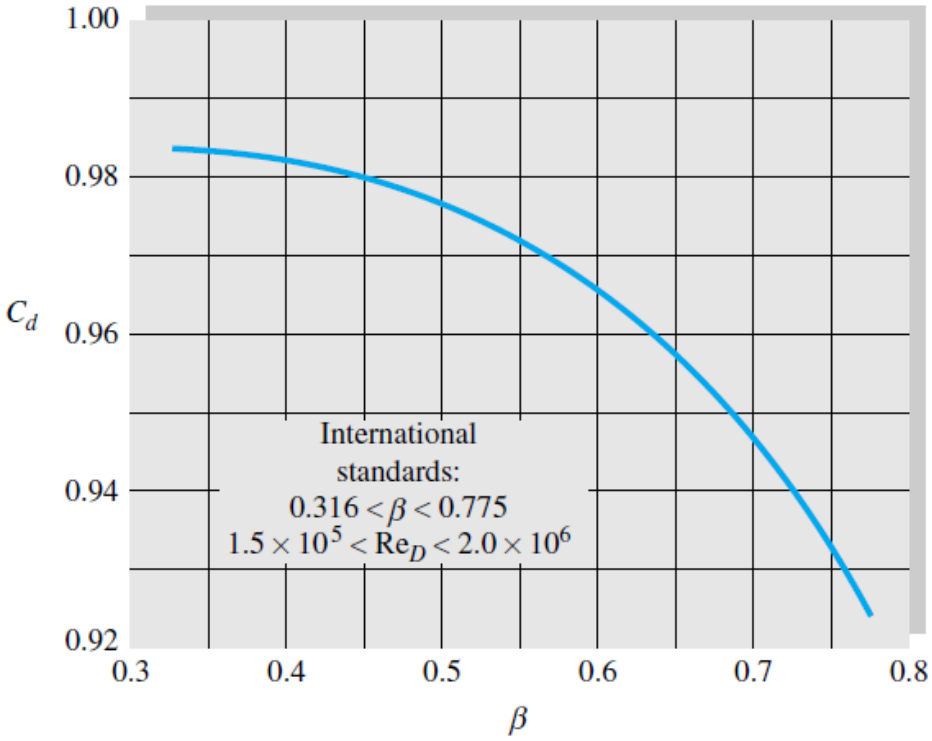


1) **Corner taps:** $F_1 = 0; F_2 = 0$
2) **D:$\frac{1}{2}$D taps:** $F_1 = 0.4333; F_2 = 0.47$
3) **Flange taps:**

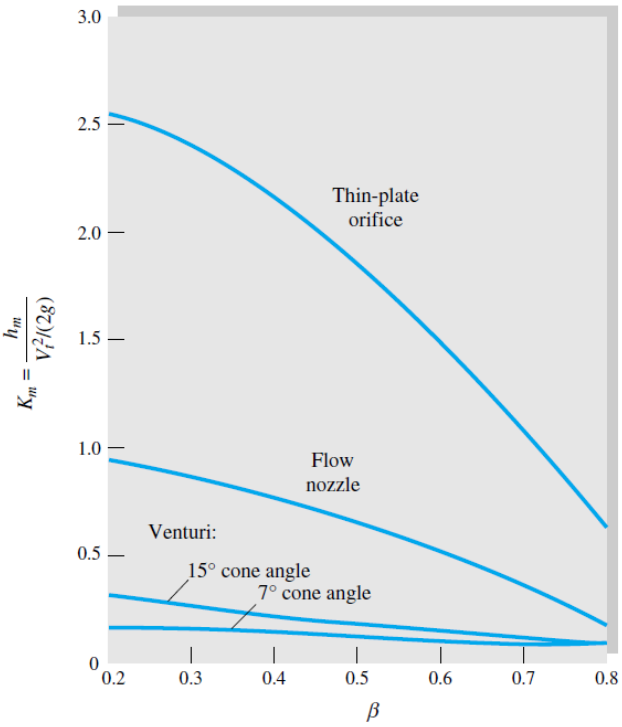
$$F_2 = \frac{1}{D\ (\text{in})} \qquad F_1 = \begin{cases} \dfrac{1}{D\ (\text{in})} & D > 2.3 \text{ in} \\ 0.4333 & 2.0 \le D \le 2.3 \text{ in} \end{cases}$$

Long radius flow nozzle: $C_D = 0.9975 - \frac{6.53\beta^{0.5}}{Re_D^{0.5}}$

Venturi meter: $C_d \approx 0.9858 - 0.196\beta^{4.5}$



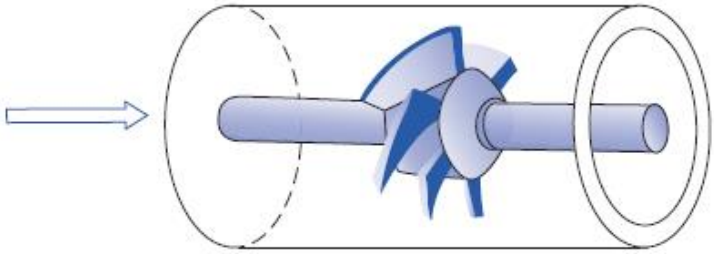
Non-recoverable Losses:

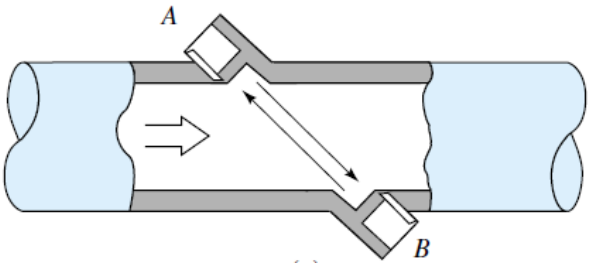


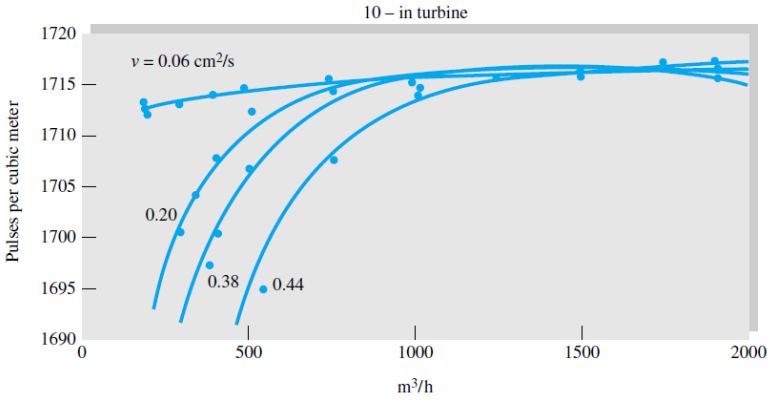
Volume-flow (mass-flow) measurements:

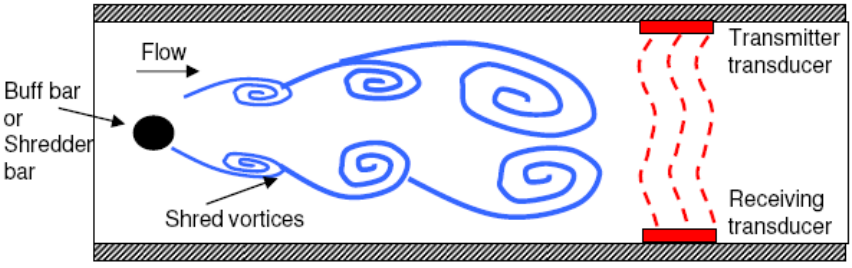
Six other widely used meters operate on different physical principles:

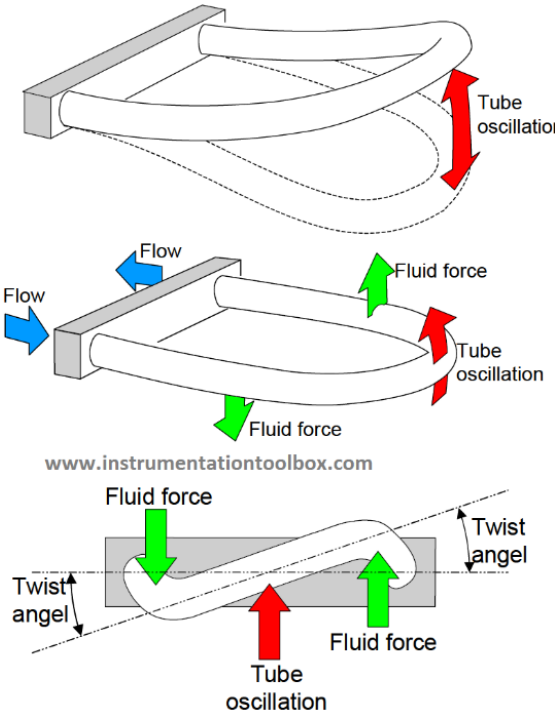
1. Turbine meter
2. Vortex meter
3. Ultrasonic flowmeter
4. Rotameter
5. Coriolis mass flowmeter
6. Laminar flow element










Tube
oscillatio
Flow
Flow
Fluid force
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oscillation
Fluid force
www.instrumentationtoolbox.com
Fluid force
Twist
angel
Twist
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Fluid force
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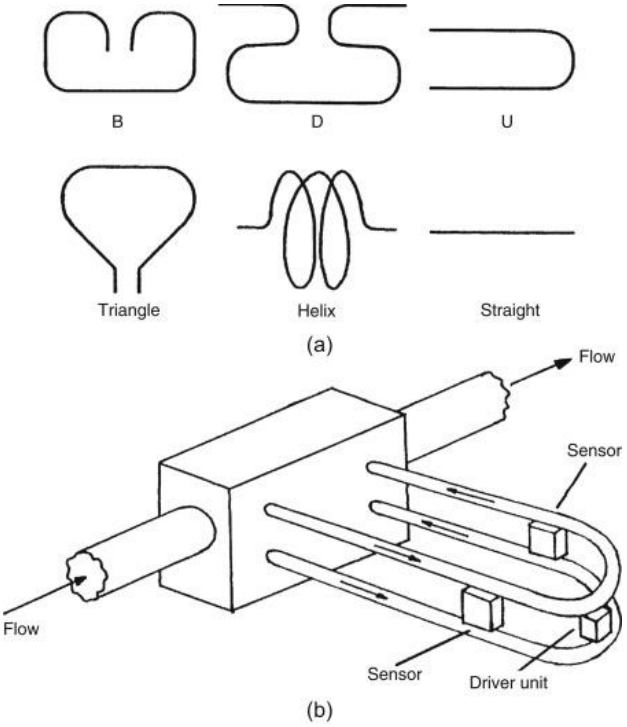
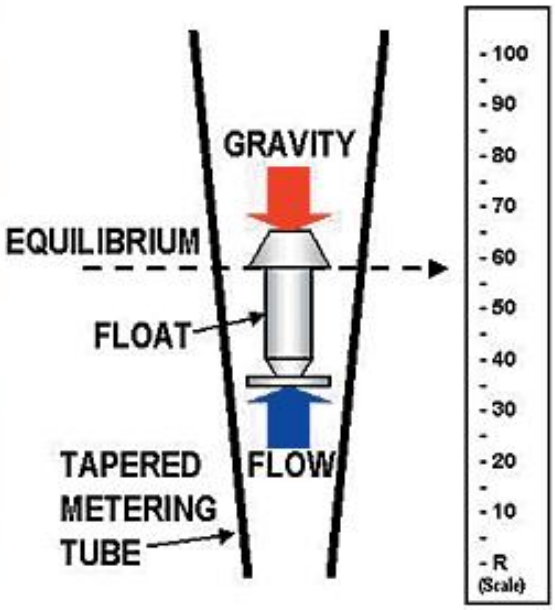
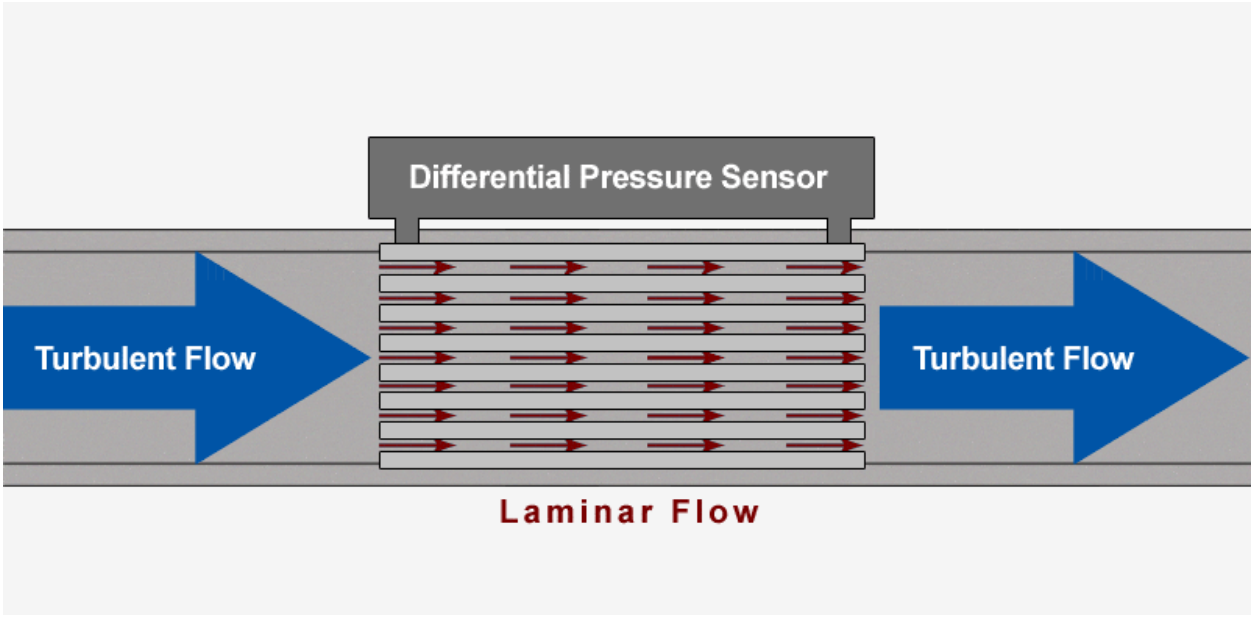

B
D
U
Triangle
Helix
Straight
(a)
Flow
Sensor
Flow
Sensor
Driver unit
(b)


GRAVITY
EQUILIBRIUM
FLOAT
TAPERED
METERING
TUBE
FLOW
- 100
- 90
- 80
- 70
- 60
- 50
- 40
- 30
- 20
- 10
- R
(Scale)


Differential Pressure Sensor
Turbulent Flow
Turbulent Flow
Laminar Flow

References:

The images and plots used in these notes are taken from:

1) Google images
2) Fox, Robert W., Alan T. McDonald, and John W. Mitchell. *Fox and McDonald's introduction to fluid mechanics*. John Wiley & Sons, 2020.
3) White, Frank M. "Fluid mechanics." (2010).