Electrical and Electronic Measurements

Lecture 9: Sensors and Transducers
Part2: Velocity, Force and Liquid Level

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Lecture Outline:

1. Velocity Sensors.
2. Force Sensors.
3. Liquid Level Sensors.

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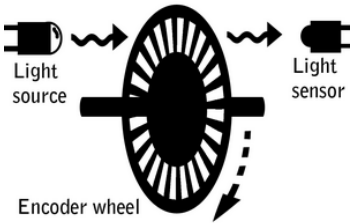
Velocity Sensors:

[1] Incremental Encoders:

- The incremental encoder used for displacement sensing can be used for the measurement of angular velocity.



Velocity Sensors:

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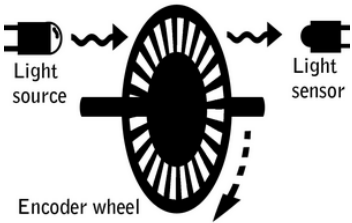
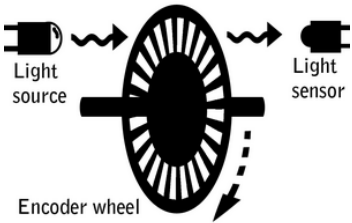
- The incremental encoder used for displacement sensing can be used for the measurement of angular velocity.
- The velocity could be determined by counting the number of pulses produced per second.



Velocity Sensors:

[1] Incremental Encoders:

- The incremental encoder used for displacement sensing can be used for the measurement of angular velocity.
- The velocity could be determined by counting the number of pulses produced per second.
- Two tracks of slots could be used to determine the direction of velocity (clockwise or counter clock wise).



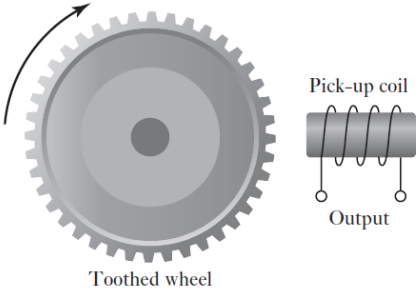
Velocity Sensors:

[2] Tachogenerators:

- The tachogenerator is used to measure angular velocity. It has two forms:

1. Variable Reluctance Tachogenerator:

- A toothed wheel of ferromagnetic material is attached to the rotating object.



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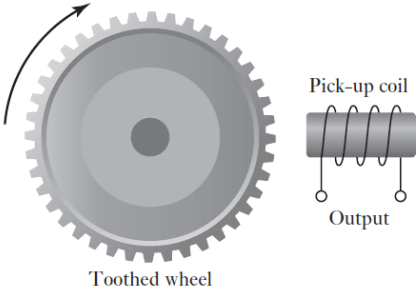

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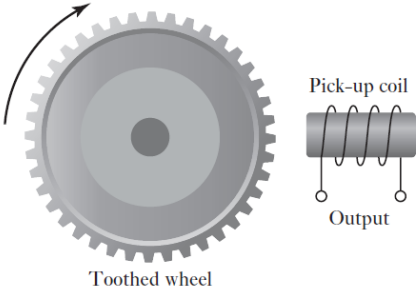
- The flux linked by a pick-up coil will be changed due to the change in the air gap.



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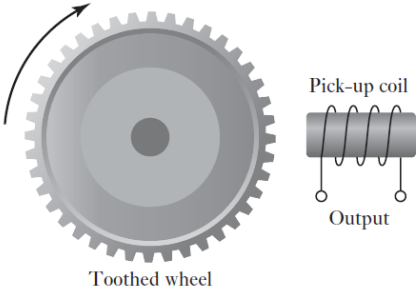
- The flux linked by a pick-up coil will be changed due to the change in the air gap. The resulting cyclic change in the flux produces an alternating e.m.f. in the pickup coil.



Velocity Sensors:

[2] Tachogenerators:

The flux ϕ changes with time as:

$$\phi = \phi_0 + \phi_a cos(n\omega t)$$

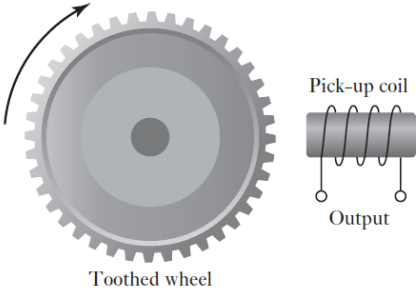
ϕ_0: The mean flux.
ϕ_z: Flux variation amplitude.
ω: Rotation speed
n: No. of teeth.

$$e.m.f = -N\frac{d\phi}{dt} = N\phi_a n\omega sin\omega t$$

N: No. of turns of pickup coil.

$$\boxed{e.m.f = E_{max} sin\omega t} \quad E_{max} \propto \omega$$

The induced e.m.f. could be shaped to a series of pulses that could be counted as a measure of angular velocity.



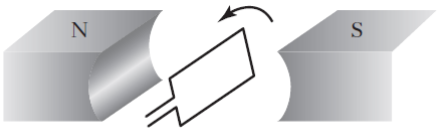
Velocity Sensors:

[2] Tachogenerators:

- The tachogenerator is used to measure angular velocity. It has two forms:

2. A.C. Generator:

- It consists of a coil, termed the rotor, which rotates with the rotating shaft inside a magnetic field produced by a stationary permanent magnet.
- When the coil rotates, an alternating e.m.f. is induced in it.
- The amplitude or frequency of this alternating e.m.f. can be used as a measure of the angular velocity of the rotor.
- The output may be rectified to give a d.c. voltage with a size which is proportional to the angular velocity.



Rotating coil

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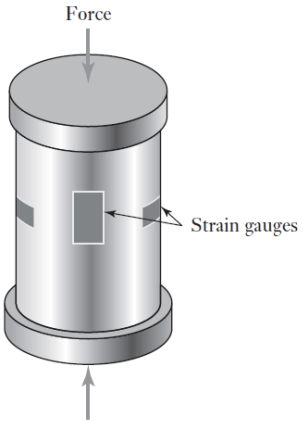
Force Sensors:

[1] Strain Gauge Load Cell:

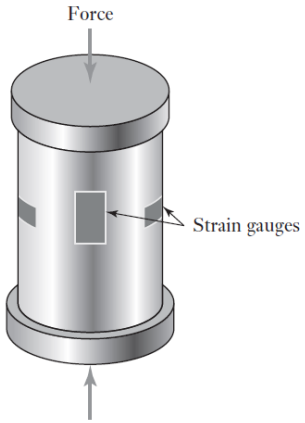
- Forces are commonly measured by the measurement of displacements.



Force Sensors:

[1] Strain Gauge Load Cell:

- Forces are commonly measured by the measurement of displacements.
- Strain gauges are used to monitor the strain produced in some member when stretched, compressed or bent by the application of the force.



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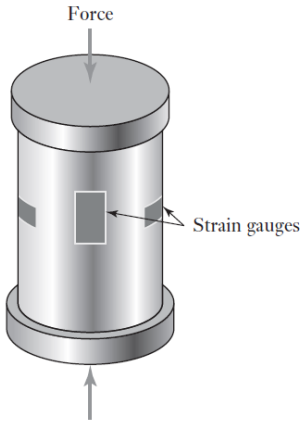
- The arrangement for measuring the force is generally referred to as a **load cell**.



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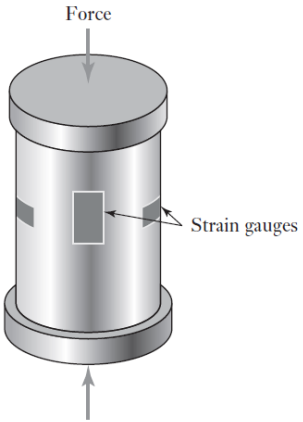
- Load cell is a cylindrical tube to which strain gauges have been attached. When forces are applied to the cylinder the resistance will change which is a measure of the applied force.



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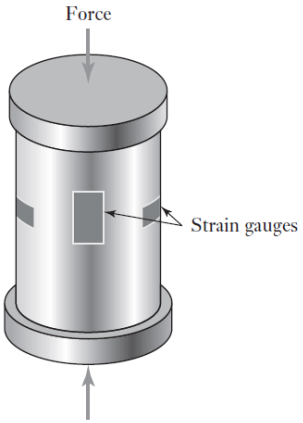
- Load cell is a cylindrical tube to which strain gauges have been attached. When forces are applied to the cylinder the resistance will change which is a measure of the applied force.
- A signal conditioning circuit is required to eliminate the effect of temperature change on the strain gauge.



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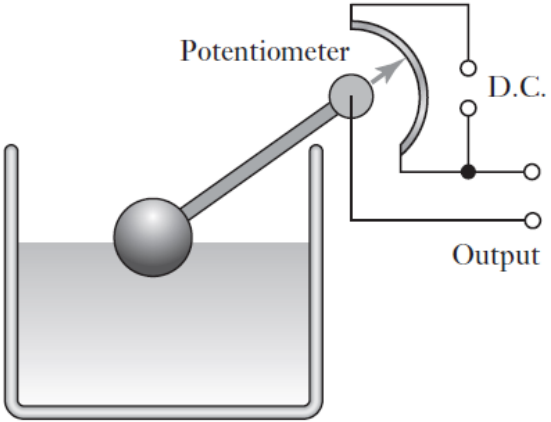
Liquid Level Sensors:

[1] Floats:

- A direct method of monitoring the level of liquid in a vessel is by monitoring the movement of a float inside that vessel.



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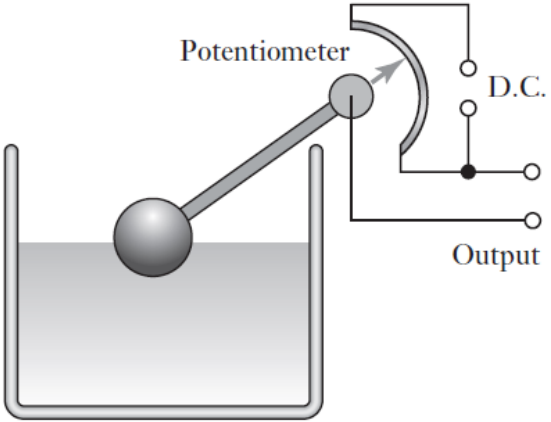
- The displacement of the float causes a lever arm to rotate and so move a slider across a potentiometer.



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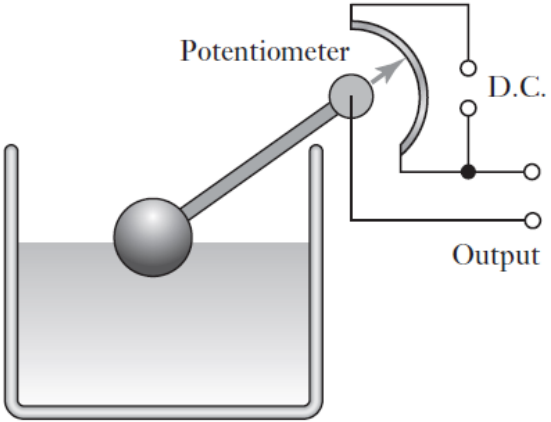
[1] Floats:

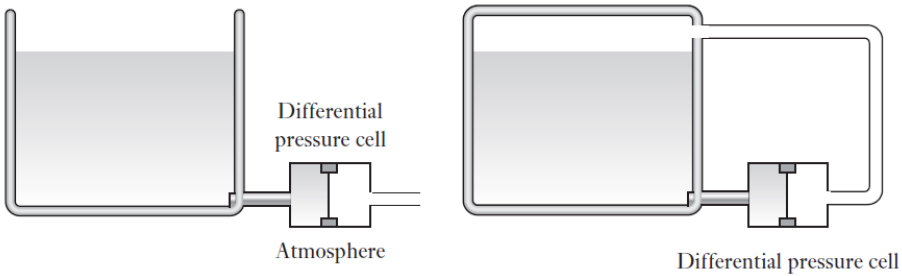
- A direct method of monitoring the level of liquid in a vessel is by monitoring the movement of a float inside that vessel.
- The displacement of the float causes a lever arm to rotate and so move a slider across a potentiometer.
- The result is an output of a voltage related to the height of liquid.



Liquid Level Sensors:

[2] Differential pressure:

- An indirect method for measuring the level of a liquid is measure the liquid which is changed according to the liquid level.
- The differential pressure cell can be used to monitor the difference in pressure between the base of the vessel and the atmospheric pressure.
- In case of closed vessel, the differential pressure cell monitors the difference in pressure between the base of the vessel and the air above the surface of the liquid.



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Best Wishes