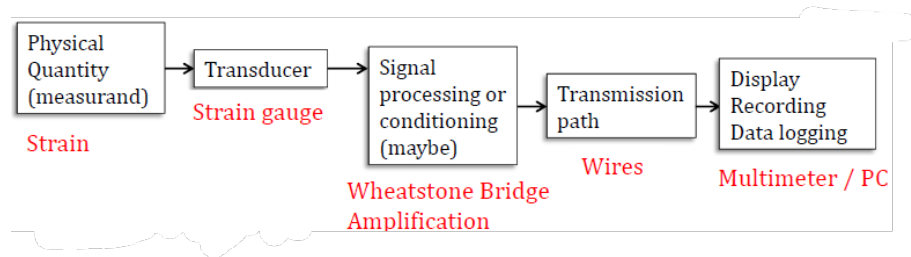
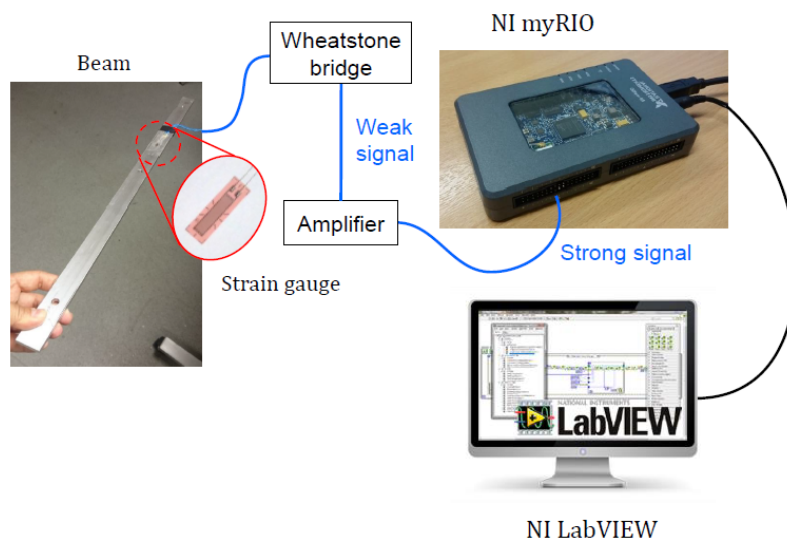


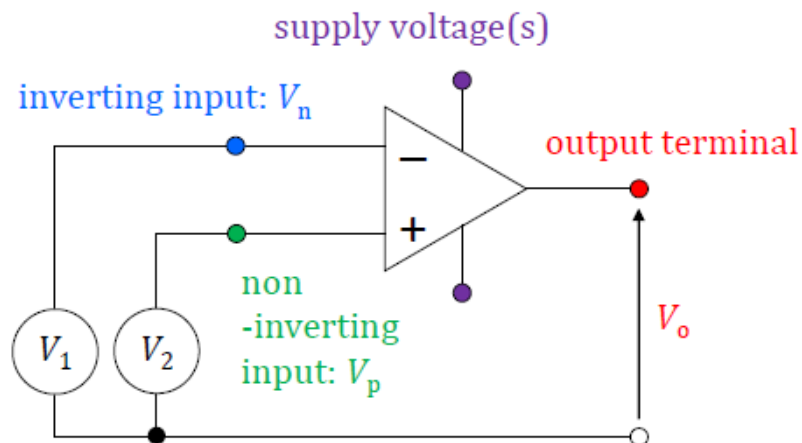
## Stages in a measurement system



### 0.1 Amplifiers

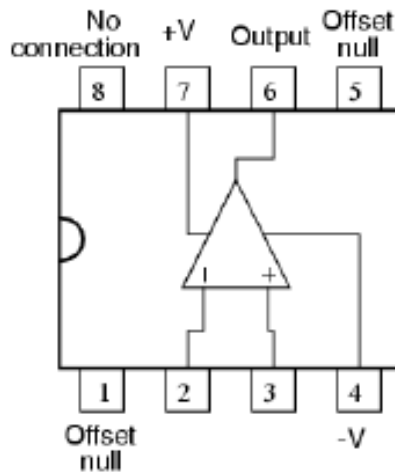


The voltage output from a transducer tends to be weak and this needs to be amplified. Operational amplifiers are normally around 1cm in size.

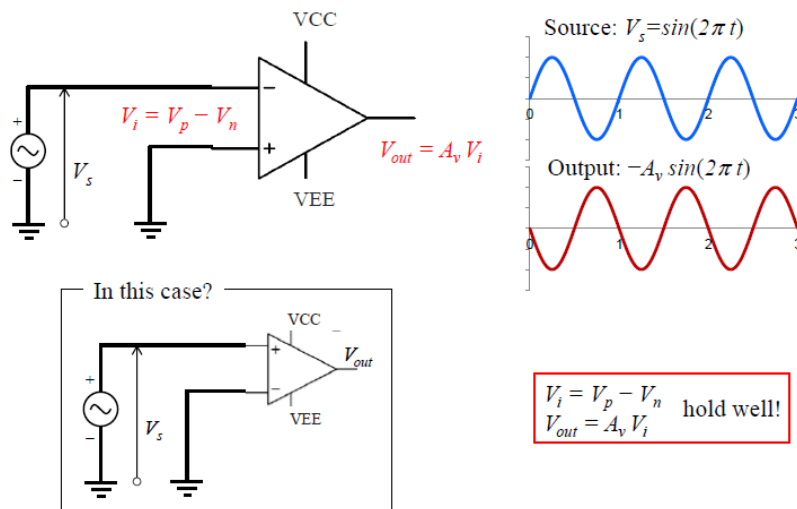


$$V_o = A_v(V_p - V_n) = A_v(V_2 - V_1) \quad (1)$$

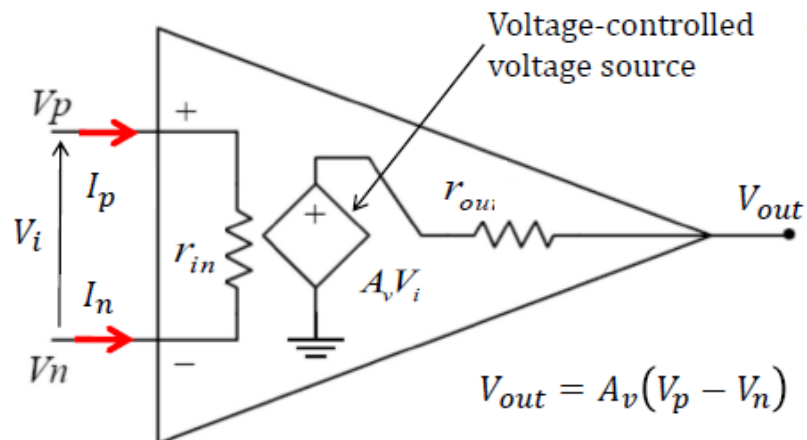
Where  $A_v$  is the gain and  $(V_p - V_n)$  can be from a Wheatstone bridge. Operational amplifiers are quite an old technology (since WW2) and are still used because they are cheap and convenient.



Pin-out for a 8-pin op-amp



### 0.1.1 Equivalent op-amp circuit and conditions of an ideal op-amp



Terminology:

- Differential input voltage:  $V_i = V_p - V_n$

- Input resistance:  $r_{in}$
- Output resistance:  $r_{out}$
- Open-circuit output voltage:  $V_{out}$
- Differential voltage gain:  $A_v$

Conditions of an ideal op-amp	In reality
No current into input terminals: $I_p = I_n = 0$	
Infinite input resistance: $r_{in} \rightarrow \infty$	$r_{in} > 200\text{k}\Omega$
Zero Output resistance $r_{out} = 0$	$r_{out} < 1\text{k}\Omega$
Infinite differential (or open-loop) gain $A_v \rightarrow \infty$	$A_v > 100,000$
Zero common-mode voltage gain $A_{cm} = 0$	$A_v$ also frequency dependant