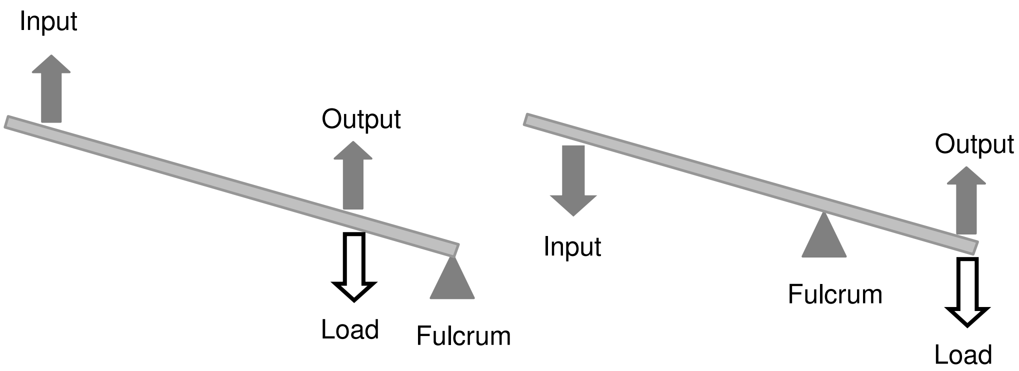
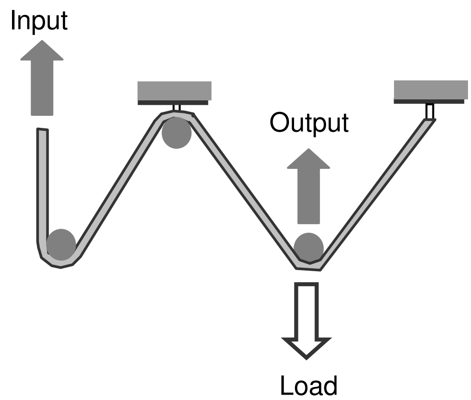
Answers to Exercises in Chapter 13

13.1 Arrangement (a) below represents a non-inverting force amplifier and a non-inverting movement attenuator. (b) represents an inverting force amplifier and an inverting movement attenuator.



(a) (b)

13.2 The arrangement below represents a non-inverting force amplifier.



13.3 Figure 13.2 is a non-inverting amplifier since the input and output are in the same direction. It could be transformed into an inverting amplifier simply by adding an extra half a turn of cable on the shaft. The input and output would then be in opposite directions.

13.4 The force applied to the brake pedal is being amplified to produce a larger force at the brake calliper (or other brake mechanism). This arrangement could also be seen as a displacement attenuator since the distance moved by the brake pedal (or the operator's foot) is much greater than that moved by the brake mechanism.

The source of power in power-assisted brakes is the engine.

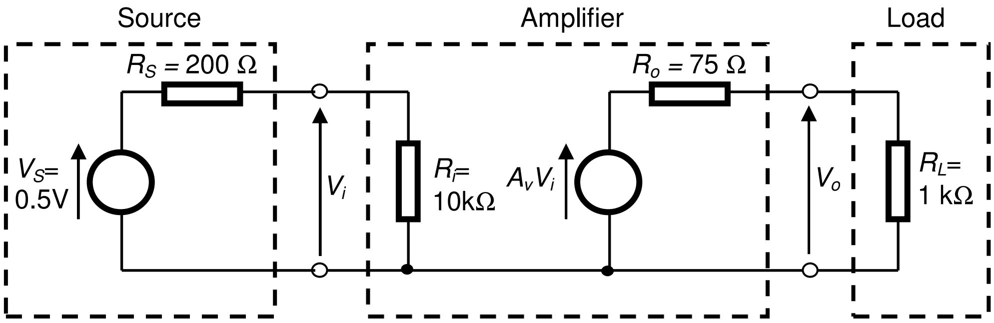
13.5 Examples include:

Mechanical:	Passive:	Screw thread	Force	
	Active:	Slipping clutch	Force	Engine
Hydraulic:	Passive:	Hydraulic jack	Force	
	Active:	Hydraulic ram	Force	Pump
Pneumatic:	Passive:	Cycle pump	Pressure	
	Active:	Master/slave ram	Force	Pump
Electrical:	Passive:	Transformer (in text) – few others at this level		
	Active:	Photomultiplier	Current	PSU
Physiological:	Passive:	Lens of eye	Image size	
	Active:	Nerve synapse	Electrical energy	Chemical energy

13.6 25 V.

13.7 0.1.

13.8 Block diagram is as follows:



$$V_i = \frac{R_i}{R_s + R_i} V_s$$
$$= \frac{10\,\text{k}\Omega}{200\Omega + 10\,\text{k}\Omega} 0.5\ \text{V}$$
$$= 0.49\ \text{V}$$

$$V_O = A_v V_i \frac{R_L}{R_O + R_L}$$
$$= 20\, V_i \frac{1\,\text{k}\Omega}{75\,\Omega + 1\,\text{k}\Omega}$$
$$= 20 \times 0.49 \frac{1\,\text{k}\Omega}{75\,\Omega + 1\,\text{k}\Omega}$$
$$= 9.12\ \text{V}$$

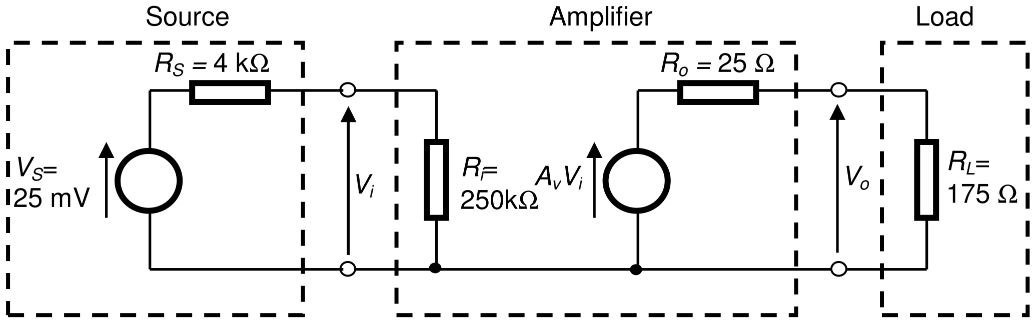
13.9

$$\text{Voltage gain } (A_V) = \frac{V_O}{V_i} = \frac{9.12}{0.49} = 18.6$$

13.10 Input power $P_i = V_i^{2}/R_i = (0.49)^2/10^4 = 24\ \mu W$. Output power $P_o = V_o^2/R_L = (9.12)^2/10^3 = 83$ mW. Power gain = $P_o/P_i = 83\ mW/24\ \mu W \approx 3.5 \times 10^3$.

13.11 The circuit of Exercises 13.8 and 13.9 can be produced by modifying the circuit of Computer Simulation Exercise 6.1.

13.12 Block diagram is as follows:



$$V_i = \frac{R_i}{R_S + R_i} V_S$$
$$= \frac{250\,k\Omega}{4\,k\Omega + 250\,k\Omega} 0.025\,V$$
$$= 24.6\,mV$$

$$V_O = A_v V_i \frac{R_L}{R_O + R_L}$$
$$= 500\,V_i \frac{1\,k\Omega}{75\,\Omega + 1\,k\Omega}$$
$$= 500 \times 0.0246 \frac{175\,\Omega}{25\,\Omega + 175\,\Omega}$$
$$= 10.8\,V$$

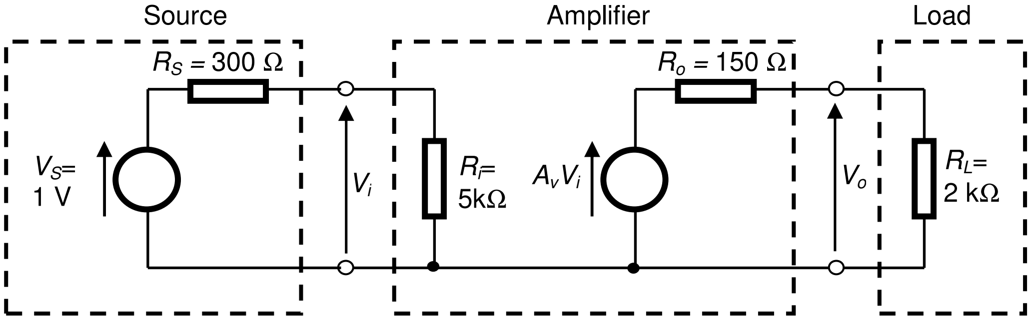
13.13

$$\text{Voltage gain } (A_V) = \frac{V_O}{V_i} = \frac{10.8}{0.0246} = 439$$

13.14 Input power $P_i = V_i^{2}/R_i = (0.0246)^2/(250 \times 10^3) = 2.4$ nW.
Output power $P_o = V_o^2/R_L = (10.8)^2/175 = 667$mW.
Power gain = P_o/P_i = 667mW /2.4nW $\approx 2.8\times10^8$.

13.15 The circuit of Exercises 13.12 and 13.13 can be produced by modifying the circuit of Computer Simulation Exercise 13.1.

13.16 The sensor produces an output voltage of 10 mV/cm. Therefore, for a displacement of 1 m the output will be 1 V. Therefore the block diagram is as follows:



$$V_i = \frac{R_i}{R_s + R_i} V_s$$
$$= \frac{5\,\text{k}\Omega}{300\,\Omega + 5\,\text{k}\Omega} 1\,\text{V}$$
$$= 943\,\text{mV}$$

$$V_o = A_v V_i \frac{R_L}{R_o + R_L}$$
$$= 15\, V_i \frac{2\,\text{k}\Omega}{150\,\Omega + 2\,\text{k}\Omega}$$
$$= 15 \times 0.943 \frac{2\,\text{k}\Omega}{150\,\Omega + 2\,\text{k}\Omega}$$
$$= 13.2\,\text{V}$$

13.17 The circuit of Exercise 13.16 can be produced by modifying the circuit of Computer Simulation Exercise 13.1.

13.18 Overall gain = 25 + 15 – 10 = 30 dB.

13.19 The gain at the upper cut-off will be 3 dB lower than the mid-band gain. Therefore the gain at the cut-off is 22 dB.

13.20 A voltage gain of 10 is a gain of 20 dB. The gain at the upper cut-off will be 3 dB lower than the mid-band gain. Therefore the gain at the cut-off is 17 dB or 7.07.

13.21 The bandwidth is the difference between the upper and lower cut-off frequencies. Here it is 25 kHz – 1 kHz = 24 kHz.

13.22 Here the bandwidth is equal to the upper cut-off frequency, which is 5 MHz.

13.23 The input voltage of a differential amplifier is the difference between its two input voltages (V_+ - V_-). In this case it is 18.3 – 18.2 = 0.1 V. Therefore the output voltage will be given by $V_0 = A_V V_i = 100 V_i = 10$ V.

13.24 The maximum voltage will be the supply voltage V and the minimum (that is, the most negative) voltage will be 0 V.