Overview

In this unit your students should:

- learn how an op-amp can be used to combine analogue signals
- understand how to use potentiometers and a summing amplifier to make a mixer
- design mixers which cannot have distorted outputs

This should not require more than 3 hours of class time.

Hour	Suggested Activity
1	Launch students straight into the **Combining signals** practical. Thisi should give them some practice at using the summing amplifier formula and show them that it works. As they finish, get them to answer questions 1 and 2 of the **Summing Signals** exercises. They will probably need to consult the text book. Ask them to answer question 1 from page 99 of the text book before the next session.
2	Students should spend this session on the **Mixing waveforms** practical. Some will find the design aspects more difficult than others, but the final outcome looks very amusing on the oscilloscope screen. Students who finish early could tackle question 3 of the **Summing Signals** exercises. Ask them to answer question 2 from page 99 of the text book before the next session.
3	Students who have successfully answered both questions form the text book should go straight on to the **Digital to analogue** practical. You could then spend valuable time with students who need your help to complete the questions from the text book and the exercises. Ask students to revise **Negative Feedback** for a formal test next session.

Model Answers

1 (a) X is at 0 V because there is negative feedback through the 200 kΩ resistor connected to the output. This requires both inputs to have the same voltage, and the non-inverting one is connected directly to 0 V.

(b) $I = V/R = (+2 - 0) / 100\times10^3 = +2.0\times10^{-5}$ A or +20 μA

$I = V/R = (-5 - 0) / 100\times10^3 = -5.0\times10^{-5}$ A or -50 μA

(c) There is no current in the inverting input of the amplifier, so the current in the 200 kΩ resistor is the sum of the currents in the two 100 kΩ resistors. These currents are in opposite directions, so their sum is +20 - 50 = -30 μA (from Z to X).

(d) $V = IR$: $0 - V_Z = -30\times10^{-6} \times 200\times10^3 = -6$ V. So $V_Z = +6$ V.

2 The maximum current in each input resistor will be $V/R = 10 / 10\times10^3 = 1\times10^{-3}$ A or 1 mA. So the maximum current in the 3.3 kΩ feedback resistor will be 3 mA, giving an output voltage of $V = IR = 3\times10^{-3} \times 3.3\times10^3 = 9.9$ V ≈ 10 V as required.