Checkpoints Chapter 10 AMPLIFIERS

Question 387

If the gain needs to be 500, the gradient must be 500. The upper limit on the linear region (angled straight line section) is 4 mV peak.
This means that the range of inputs is

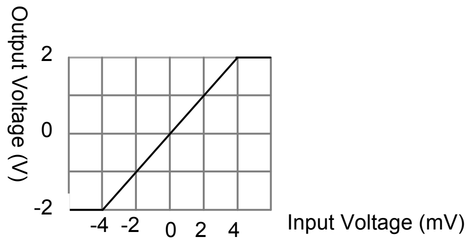
2×4 mV = 8 mV.

The linear region needs to be centred on

0 ± 4 mV

The output voltage needs to be ×500,
$\therefore$ 4 mV × 500 = 2 V, and -4 mV × 500 = -2 V.

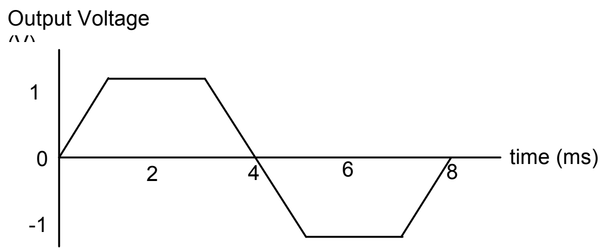
Hence the scale on the graph needs to be as follows:



Question 388

The output signal will have exactly the same shape, but the scale on the vertical axis will be ×500 the original.
From the original graph the input voltage varies from +2 mV to -2 mV (assumed).
$\therefore$ the output voltage will range from

$(+ 2 \times 10^{-3} \times 500)$
$= 1$ V to $(- 2 \times 10^{-3} \times 500)$
$= -1$ V



Question 389

The gain of the amplifier is given by

$$\frac{V_{OUT}}{V_{IN}} = \frac{4 \text{ divisions}}{2 \text{ divisions}}$$
$$= \mathbf{\times 2}.$$

The voltage is also **inverted** since the output graph is upside down compared with the input graph.

Question 390

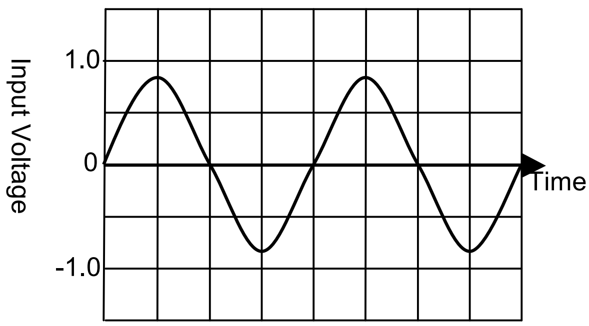
If $V_{OUT\ (Peak\ to\ Peak)} = 2V$, then $V_{IN\ (Peak\ to\ Peak)} = 1$ V.
$\therefore$ Each division of the graph = 0.5 V.
This means that V_{IN} is centred on 1.5 V with $\pm 0.5\ V_{peak}$.
$\therefore$ DC component = 1.5 V, AC = ±0.5 V_{peak}

Question 391

The voltage gain is the gradient of the graph, in the linear region.
The gradient is $\frac{-12}{2} = -6$

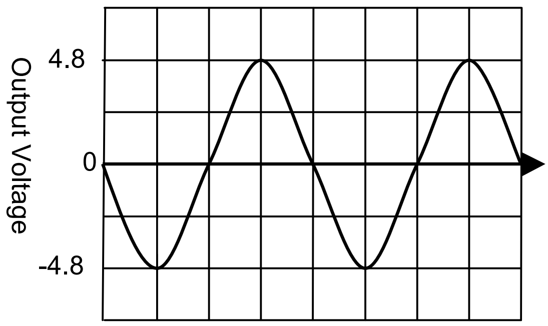
$\therefore$ gain is ×6 (inverting) (ANS)

Question 392

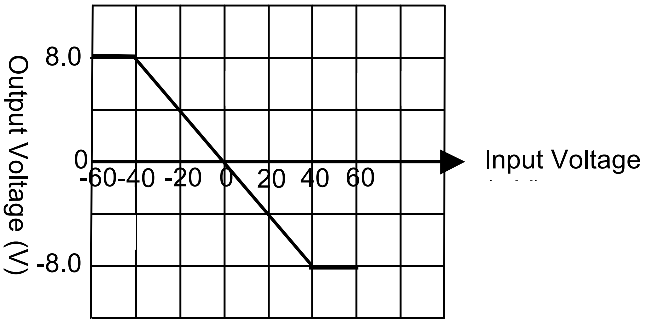


Question 393

The linear region of the graph includes input voltages between -1.0 and +1.0V.
Since the gain is ×6, this means that the output voltage will be not be clipped and will be between ±4.8 V.



Question 394



Question 395

The voltage gain is the gradient of the graph, in the linear region.

The gradient is $\frac{-16}{80 \times 10^{-3}} = -200$

$\therefore$ **gain is ×200 (inverting) (ANS)**

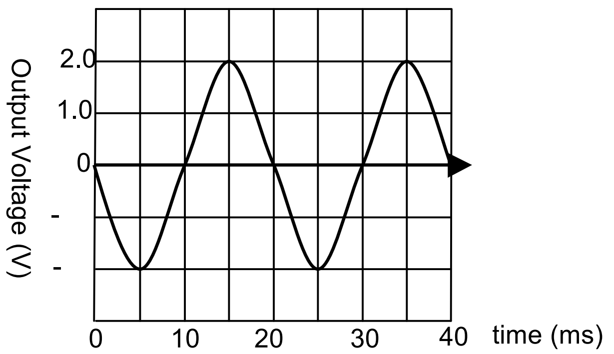
Question 396

The maximum AC voltage that can be amplified without distortion needs to be within the range of ±40 mV, as long as the signal is centred on 0V.

$\therefore$ range of **80 mV$_{\text{peak-peak}}$. (ANS)**

Question 397

The maximum input is 10mV, this is well within the linear range of the amplifier, so there will not be any distortion (clipping) of the input signal. Therefore the output signal will be a sinusoidal wave.
The amplification is ×200 and inverting. This means that 10 mV ×-200 = -2.0 V,
and -10 mV ×-200 = 2.0 V.



Question 398

To amplify 2.4 mV to 3.6 V the signal needs to be increased by a factor of ×1500.

$\therefore$ **A (first line) (ANS)**

The answer in the back of the book is incorrect. The logic is good.

Question 399

To eliminate the distortion, due to clipping, the output of amplifier A_1 must be no larger than 48 mV.
If the input signal is 2.4 mV then

A_1 = ×20 (ANS)

Question 400

The RMS voltage generated is actually the input to the amplifier. Therefore the RMS output has been multiplied by ×150, from the gain of the amplifier.
This means that the input signal needed to be 2.1V ÷ 150 = 14 mV.
From the table of values given, this will be equivalent to a speed of **1.4 m/s. (ANS)**

Question 401

To convert RMS to peak-peak, multiply RMS × $2\sqrt{2}$

$\therefore 2.1 \times 2\sqrt{2}$ = **5.9 V (ANS)**

Question 402

The range of voltages that can be amplified without clipping (distortion), is from -12 mv to 12 mV.
Therefore, 24 mV. This means that the peak to peak range of the AC must be 24 mV.

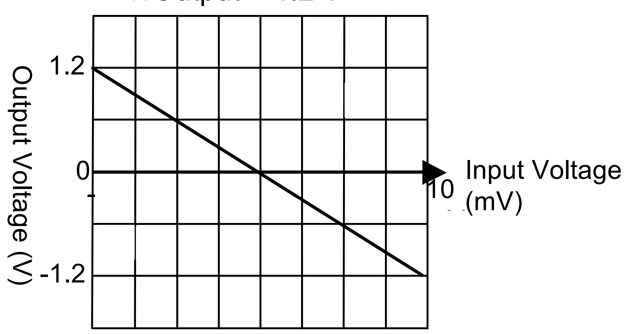
To convert peak to peak to RMS divide by $2\sqrt{2}$

$\therefore 24 \div 2\sqrt{2}$ = **8.5 mV (ANS)**

Question 403

If the gain is ×120, then a 10 mV input will lead to a 10 × 10^{-3} × 120 output.

$\therefore$Output = 1.2 V



Note that the vertical scale used in the answer is a little misleading.

Question 404

Amplification = ×200,

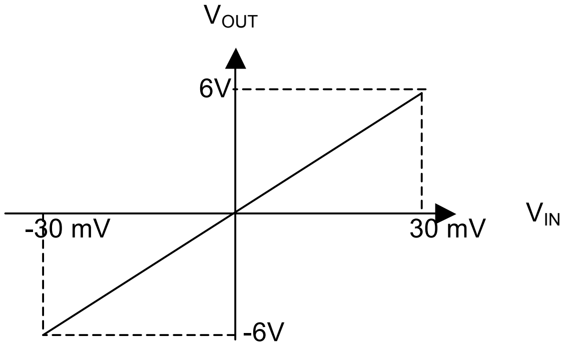
∴23 mV (within linear range) will be amplified by a factor ×200, producing a 4.6 V_{RMS} signal.

4.6 V_{RMS} = 4.6 × 2$\sqrt{2}$ $V_{peak\text{-}peak}$

= **13 $V_{peak\text{-}peak}$. (ANS)**

Question 405

If V_{OUT} = ±6 V, then V_{IN} = ±6 ÷ 200 = ±30 mV



Question 406 (1998 Q 5, 2m)

The signal generator has a sinusoidal output with a peak to peak voltage of 50.0 mV.

Therefore the RMS output will be 50.0 ÷ 2$\sqrt{2}$

= **17.7 mV (ANS)**

Question 407 (1998 Q6, 2m)

The gain of an amplifier is the ratio of $\frac{V_{out}}{V_{in}}$.

In this case that is equal to $\frac{5}{50\times10^{-3}}$

= **100 (ANS)**

The value for V_{out} is read from the CRO screen. The graph is 5 squares high (peak to peak) and the scale is one square = 1.0 Volt.

Question 408 (1998 Q7, 2m)

The frequency of the output is given by f = $\frac{1}{T}$.

In this case T = 4 squares on the CRO. On the time axis each square is equal to 0.5 ms. So the period is 2.0 ms.

$\therefore f = \frac{1}{T} = \frac{1}{2\times10^{-3}}$

= **500 Hz (ANS)**

Question 409

$$\text{gain} = \frac{\Delta V_{out}}{\Delta V_{in}}$$

$$50 = \frac{12}{\Delta V_{in}}$$

$$\therefore \Delta V_{in} = \frac{12}{50}$$

$$\therefore \Delta V_{in} = 0.24\ V_{peak}$$

$$\therefore \Delta V_{in\ RMS} = \frac{0.24}{\sqrt{2}}$$

= 0.17 V_{rms} (170 mV) **(ANS)**

Question 410

There will be no difference in the sound.

Question 411

Find the ratios of the peak values of both output and input voltages.

$$\text{gain} = \frac{\Delta V_{out}}{\Delta V_{in}}$$

$$\text{gain} = \frac{1.0}{-0.2}$$

∴ gain = **× 5 (ANS)**

Question 412

The frequency of the output is given by f = $\frac{1}{T}$.

From the graph the period (1 cycle) is 20 ms.

$\therefore f = \frac{1}{T} = \frac{1}{20\times10^{-3}}$

= **50 Hz (ANS)**

Question 413

The peak output is 1.0 V.

To convert V_{peak} to V_{RMS} divide by $\sqrt{2}$.

∴ 1.0 ÷ $\sqrt{2}$ = **0.71 V (ANS)**

Question 414

Power is given by P = VI.

To find the P_{RMS} use V_{RMS} × I_{RMS}.

(Use 10 mA as 10 × 10^{-3}A)

∴ P_{RMS} = 0.71 × (10 × 10^{-3} ÷ $\sqrt{2}$)

= **5 mW (ANS)**

Question 415

To convert peak to peak to RMS divide by $2\sqrt{2}$.

$\therefore 2.5 \div 2\sqrt{2}$ = **0.88 V** **(ANS)**

Question 416

The frequency of the output is given by $f = \frac{1}{T}$.

$\therefore T = \frac{1}{f} = \frac{1}{1200}$
= **8.3×10^{-4}s**
= **0.83 ms** **(ANS)**

Question 417

The maximum gain possible is given by
14 ÷ 2.5 = 5.6
∴ B, C, D are all possible **(ANS)**

Question 418 **(2000 Question 13)**

$\text{gain} = \frac{\Delta V_{out}}{\Delta V_{in}}$

$\text{gain} = \frac{2 - 0}{{}^{-}0.04 - 0}$

Gain = × (-) 50
∴ magnitude of gain is **× 50** **(ANS)**

Question 419 **(2000 Question 14)**

The amplification is linear and inverting.
∴ A (ANS)

Question 420 **(2008 Q5, 2m, 70%)**

The magnitude of the amplification is given by the gradient of the graph.

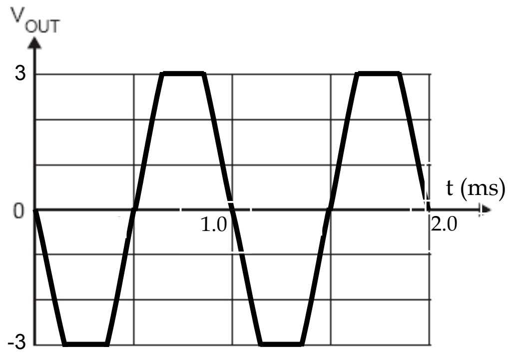
$= \frac{6}{120 \times 10^{-3}}$

= × 50 **(ANS)**

Question 421 **(2008 Q6, 3m, 50%)**

The amplifier has a region of linear amplification when the input voltage is between ±60mV.
The negative slope demonstrates that the output signal is inverted from the input signal.
The horizontal sections v_{in} >+60 mV,
v_{in} < -60mV will clip the output signal, since in these regions the amplification is zero and
v_{in} > +60mV will clip the output signal, since in these regions the amplification is zero.

The output signal is inverted, amplified by 50, and clipped when the magnitude of the input signal is greater than 60mV.
The maximum value is 60 mV × 50 = 3 V.



Question 422 **(2010 Q9, 2m, 50%)**

The voltage gain of the amplifier is the gradient of the linear region of the $V_{OUT} - V_{IN}$ graph.
The linear region is before the clipping occurs.

Use $\text{Gain} = \frac{V_{out}}{V_{in}}$

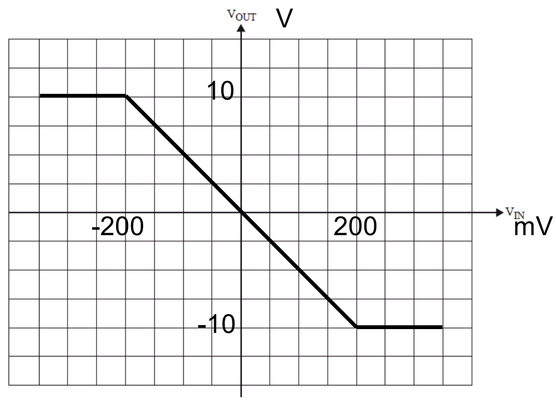
Use the points (on the graph) V_{OUT} = -10,
When V_{IN} = 200 mV

$\therefore \text{Gain} = \frac{-10}{0.2}$

(The negative values are not required for the magnitude of the gain).
∴ Gain = (-) 50 **(ANS)**

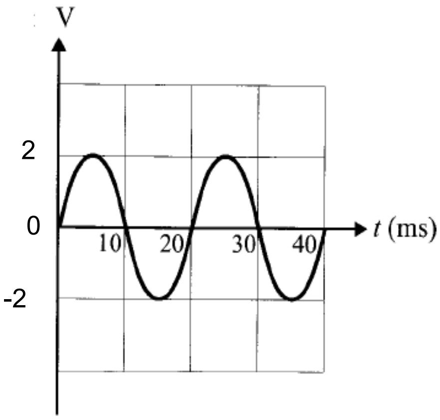
Question 423 **(2010 Q10, 3m, 70%)**

If you are in doubt about how to draw this, just plot a few points from the previous two graphs.
i.e. At t = 0, the voltages are (0, 0),
at t = 5, the voltages are (200, -10)
clipping occurs once V_{IN} > 200 mV



Question 424 (2011 Q11, 2m, 65%)

The signal will have the same shape, with a maximum value of 2V.



Question 425 (2011 Q12, 2m, 35%)

Clipping will occur when the input voltage is outside the linear region of the amplifier. This is when the input voltage is greater than 10 mV or less than -10 mV.
If the input signal is clipped the output will be a flat line at ± 4 V.

Question 426 (2012 Q4a, 1 mark, 67%)

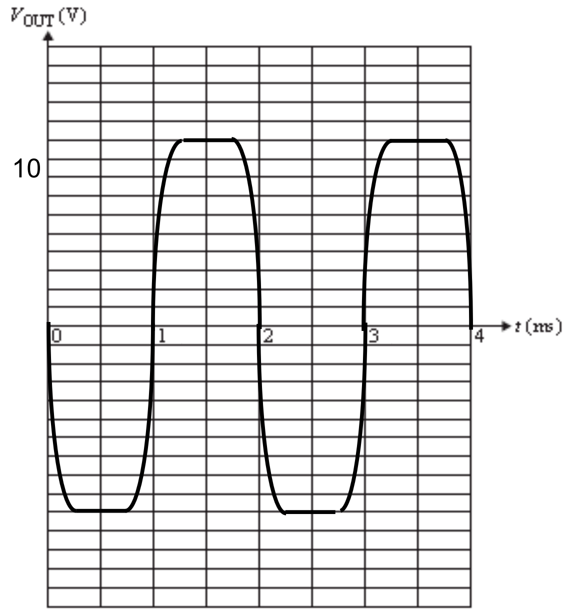
The gain is the gradient of the line in the linear region.
Make sure that you read the axes carefully.

$$\therefore \frac{\text{rise}}{\text{run}} = \frac{20}{80 \times 10^{-3}}$$

$\therefore$ **Gain = 250 (ANS)**

Question 427 (2012 Q4b, 3m, 83%)

The input signal will be clipped at ±40 mV. The output will be inverted, because the gradient of the characteristic curve is negative.
The scale on the vertical axis will be 250 times the original. Therefore 40 mV will become -10V



Question 428 (2013 Q13a, 2m, 55%)

The gain of the amplifier is the gradient in the linear region.

$$\text{gain} = \frac{\Delta V_{out}}{\Delta V_{in}}$$

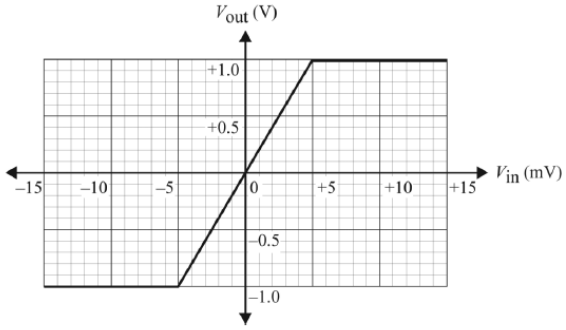
$$\text{gain} = \frac{{}^{-}8 - 8}{0.020 - {}^{-}0.020}$$

$\therefore$ **gain = (-) 400 (ANS)**

Question 429 (2013 Q13b, 2m, 60%)

The negative gradient of the Voltage input vs output graph means that an increase in input voltage produces a decrease in the output voltage.
Therefore it is described as an inverting amplifier.

Question 430 (2014 Q10a, 3m, 70%)



The actual exam question also included the sentence
"The maximum magnitude of the voltage output of the signal is 1.0 V, whether positive or negative."
This was required to get the shape of the graph.

Question 431 (2014 Q10b, 3m, 67%)