General License Class

Math Review

Decibels
Ohm's Law & Joule's Law
Basic Components in Parallel
Basic Components in Serial
Impedance Matching
AC Power
Amplitude and Frequency Modulation
Antenna Wave Length

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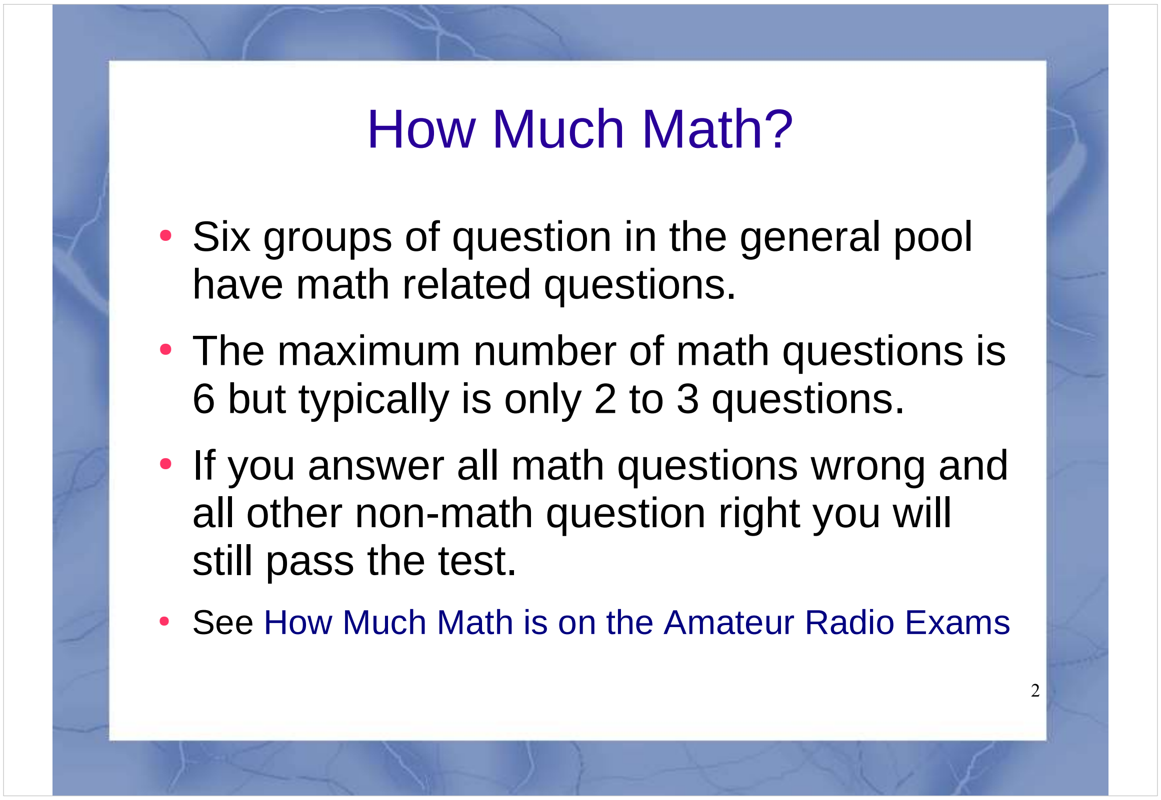
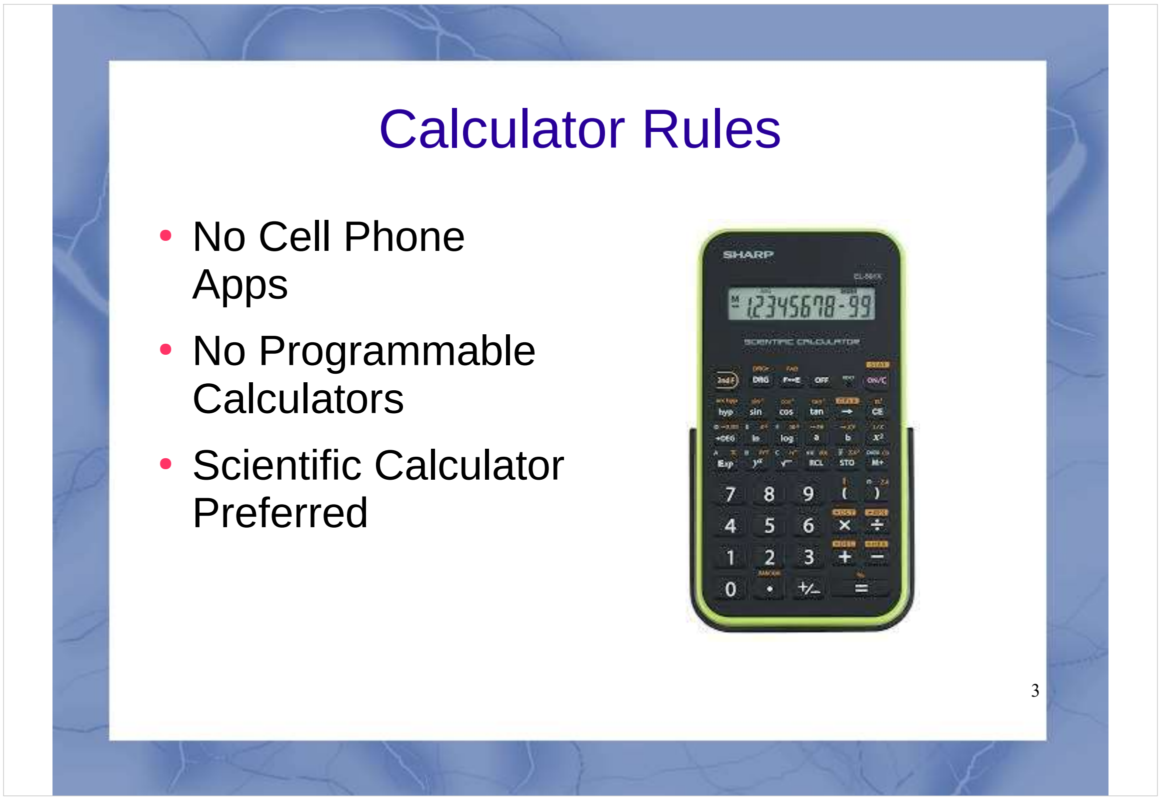
This is a review of the math topics that related to the General Class license examination (element 3).

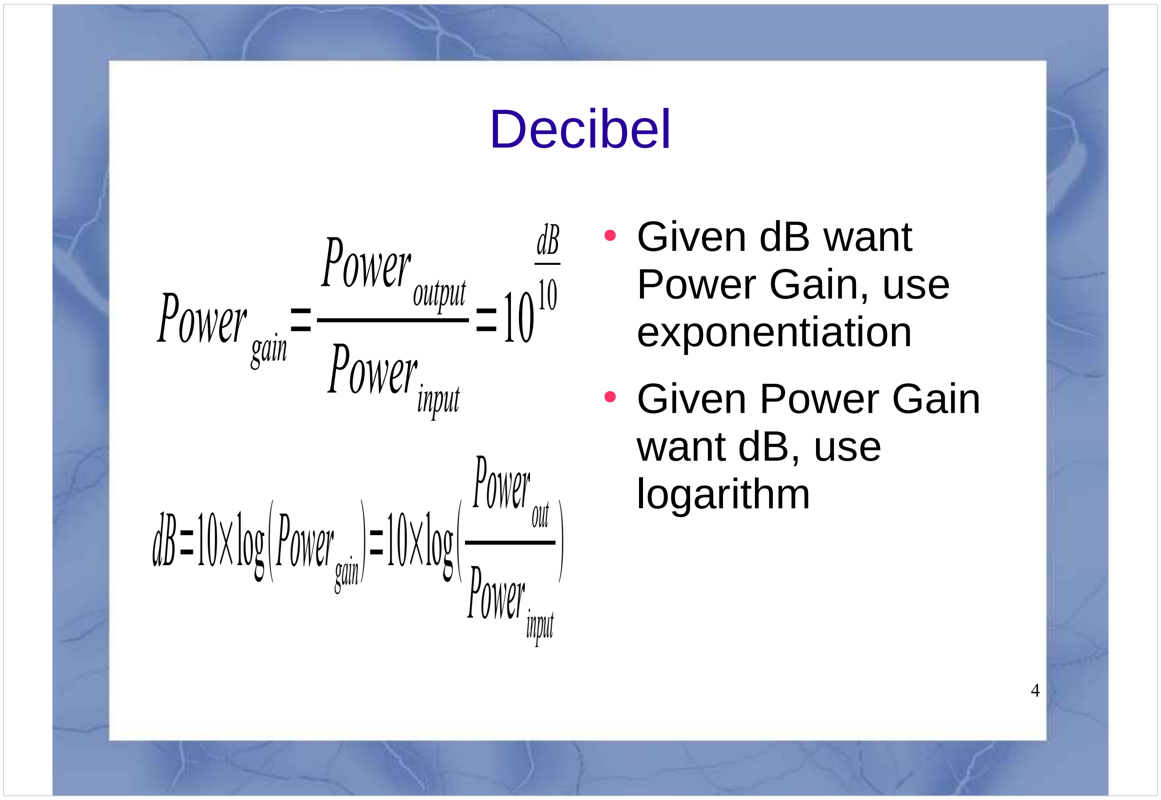


The six groups with math questions are G4D, G5B, G5C, G8B, G9A and G9B. But these section also have non-math questions. On average one only has 3 to 2 math questions to answer on the element 3 exam.

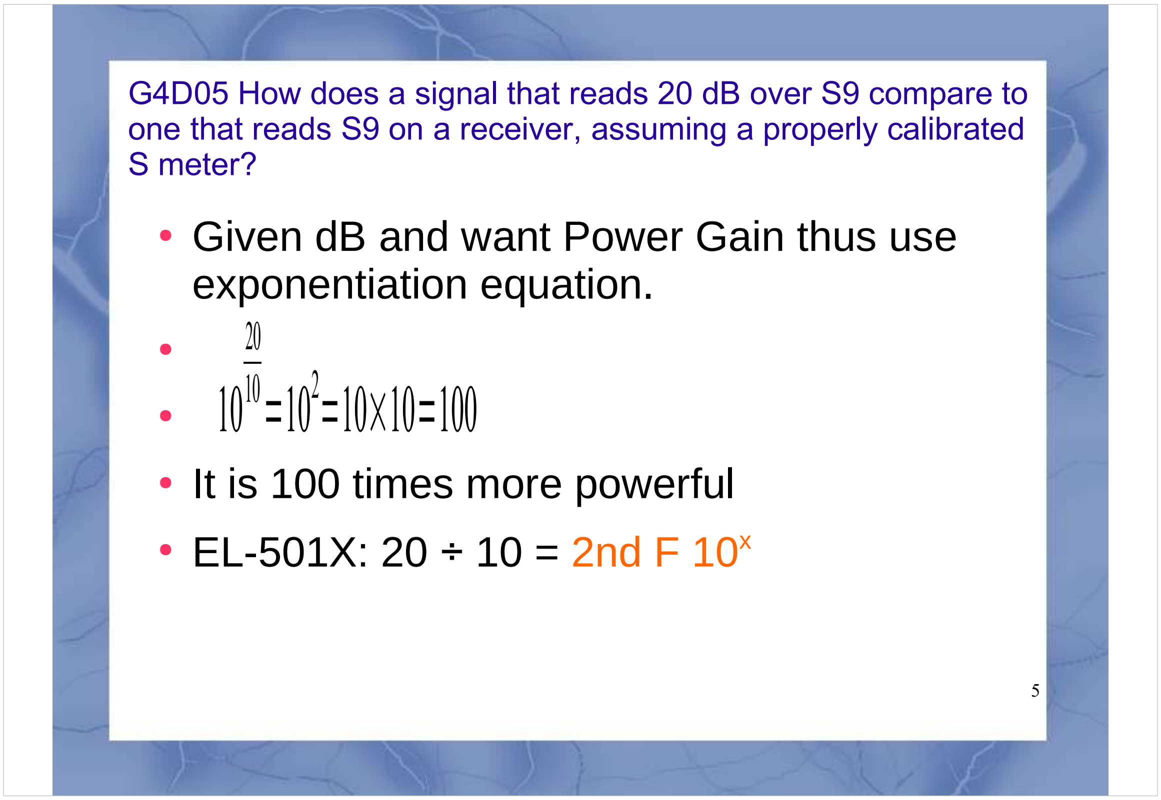
Group	Math Questions	Non-Math Questions
G4D	1	10
G5B	8	5
G5C	12	6
G8B	2	8
G9A	5	10
G9B	3	9



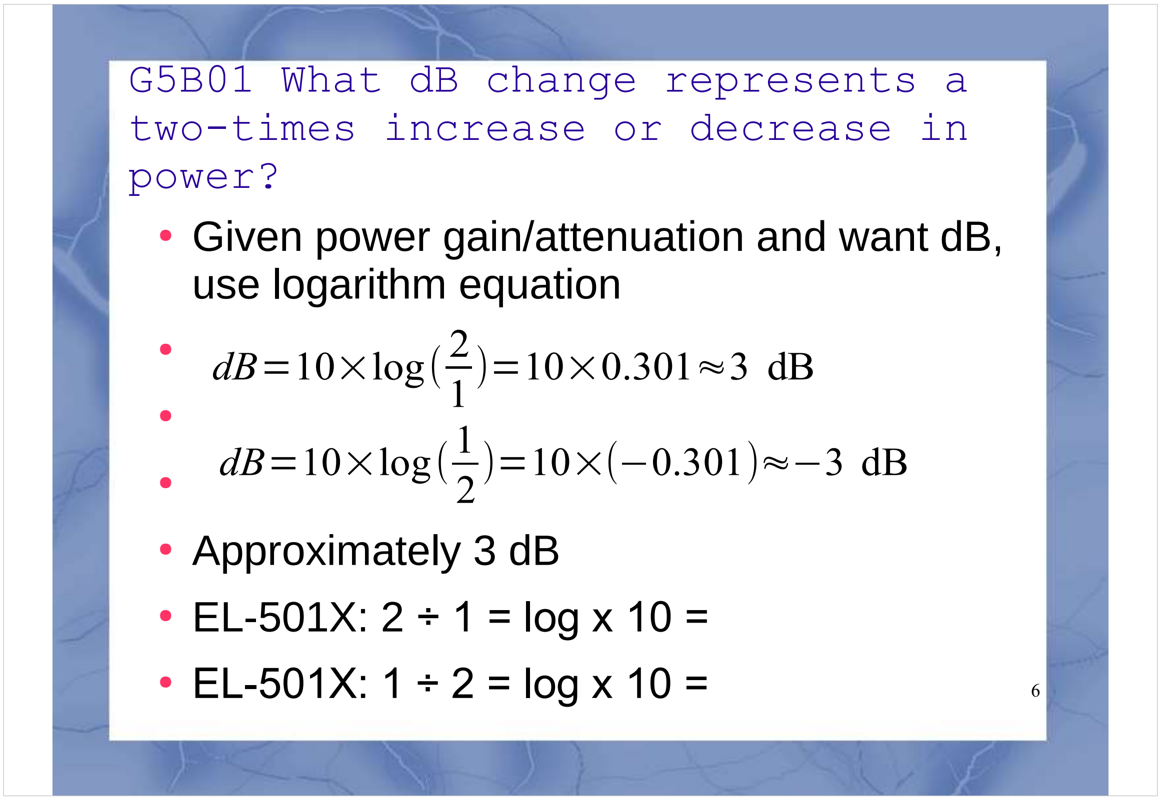
No wireless devices may be used during the exams. Therefore cell phone calculator applications are not allowed. If your calculator is programmable you must demonstrate that all memory has been cleared. If you can't and won't demonstarte that memory is cleared, you cannot use it during the exam. The provided scientific calculator is preferred, but you may bring your own.



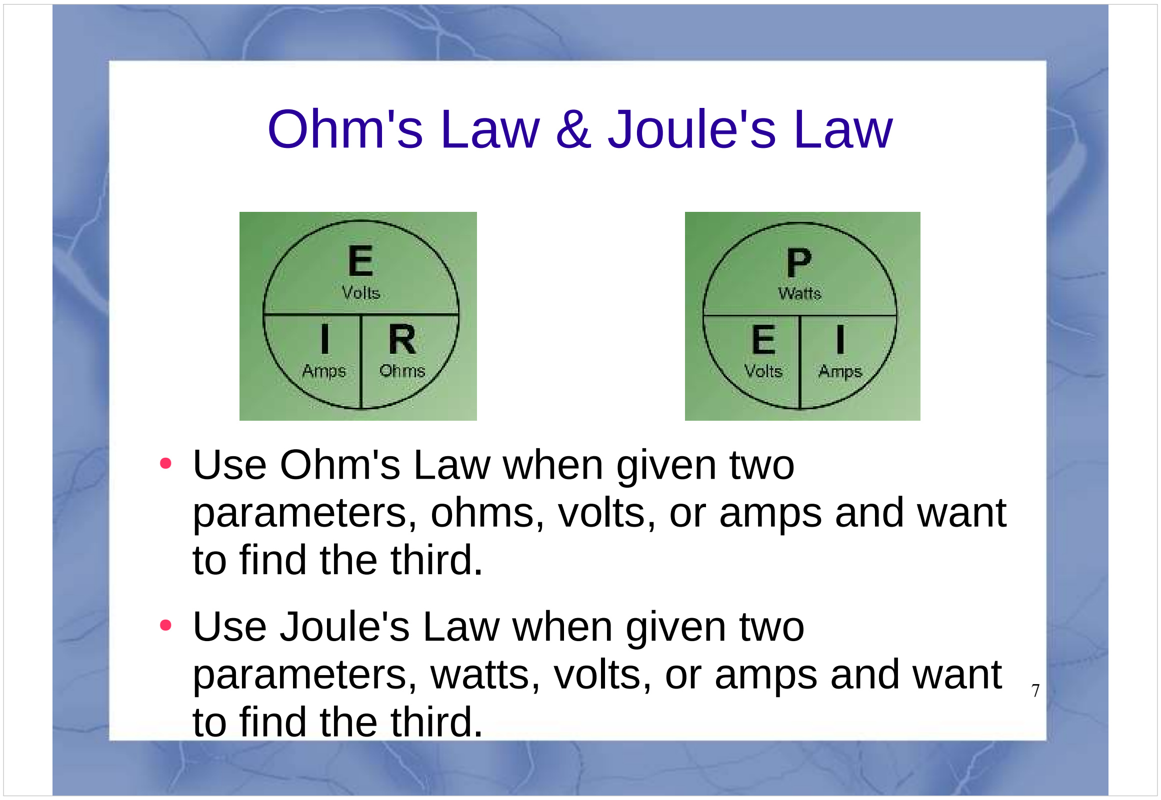
The top equation converts decibel values to power gain by taking the anti-log. The bottom equation converts from power gain to decibels using the common logarithm. Both of these equations can be evaluated using a scientific calculator. A four function calculator will not have logarithm or anti-logorithm keys.



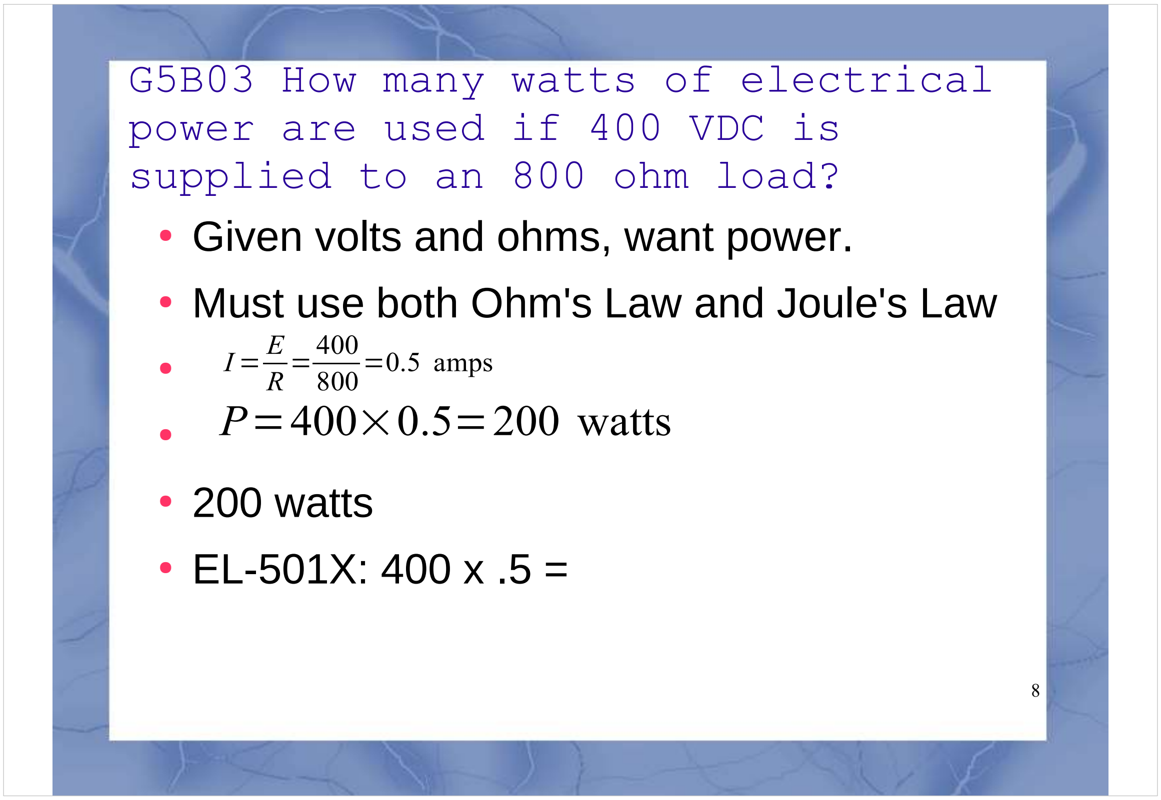
To convert from 20 dB to the power gain ratio one must evaluate anti-logarithm. Convert decibels to Bels by dividing by 10. Then use the result as a power of ten and you have the answer.



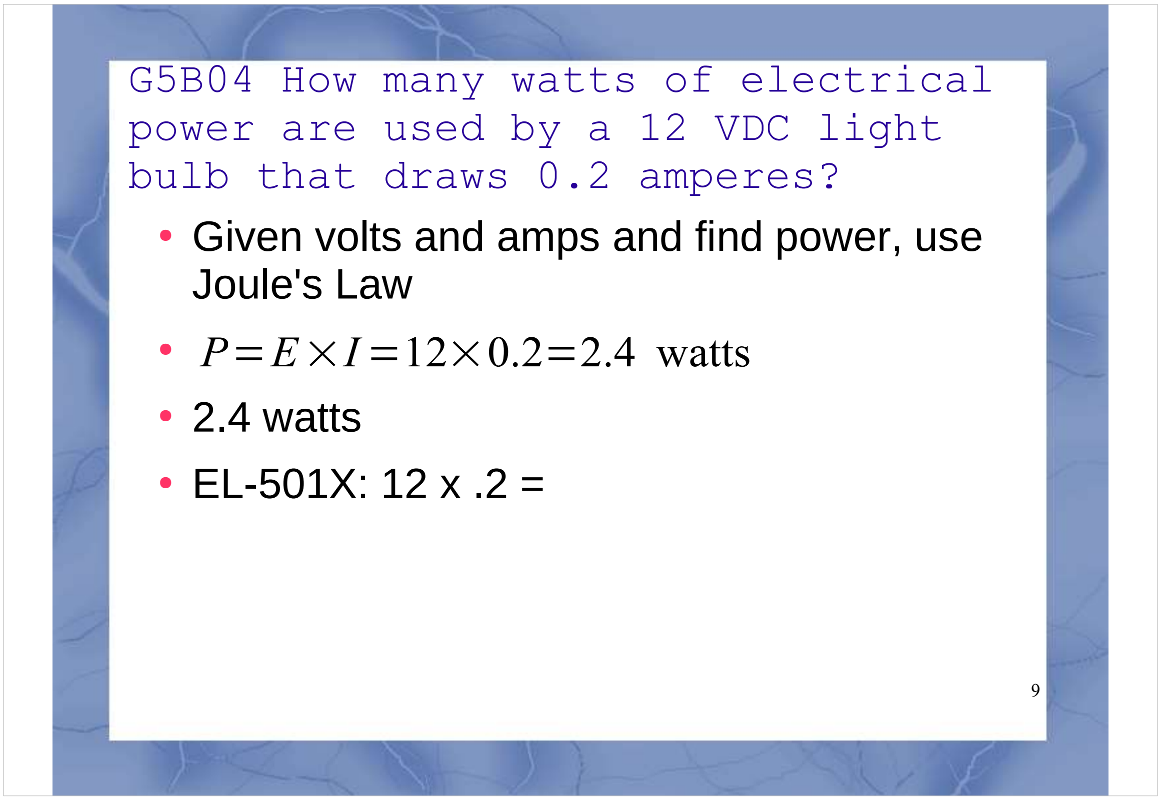
A two-times increase is 2 to 1 or 2 over 1. But a two-times decrease is 1 to 2 or 1 over 2. As shown above to result is +3 dB and -3 dB respectively. Approximately 3 dB is the answer. Note the approximate is because the result is slightly larger than 3.



Ohm’s Law and Joule’s Law relate voltage, current, resistance and power. Sometimes you must solve for either voltage or current in Joule’s law and then substitute that value into Ohm’s Law, or vise verse.



The problem wants power which requires Joule’s Law, but both voltage and current are not know. We will use Ohm’s Law to find the current and make the necessary substitution into Joule’s Law.



Power is wanted and we have both voltage and current. Therefore we only need use Joule’s Law.

Basic Components

- Resistors in series share current
- $R_{eq} = R_1 + R_2 + \ldots + R_n$
- Resistors in parallel share voltage
- $\frac{1}{R_{eg}} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots + \frac{1}{R_n}$
-

	Series	Parallel
Inductor	As R in series	R in parallel
Capacitor	As R in parallel	As R in series

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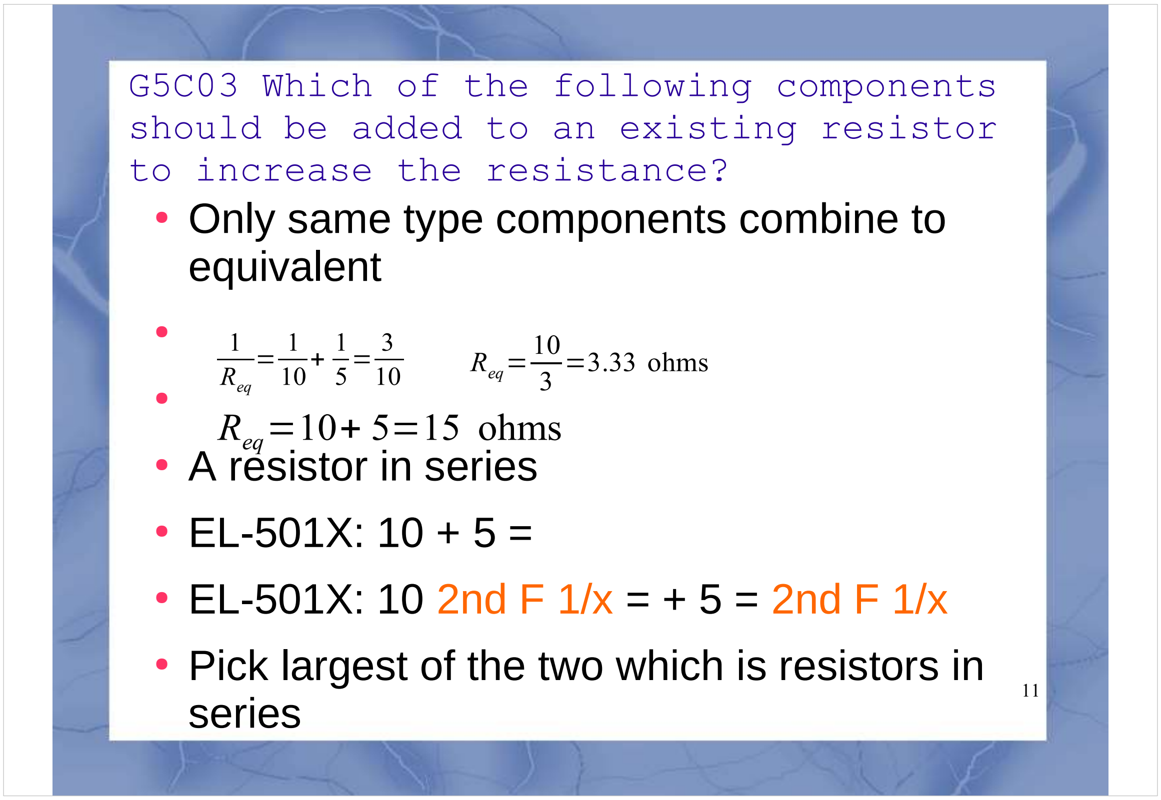
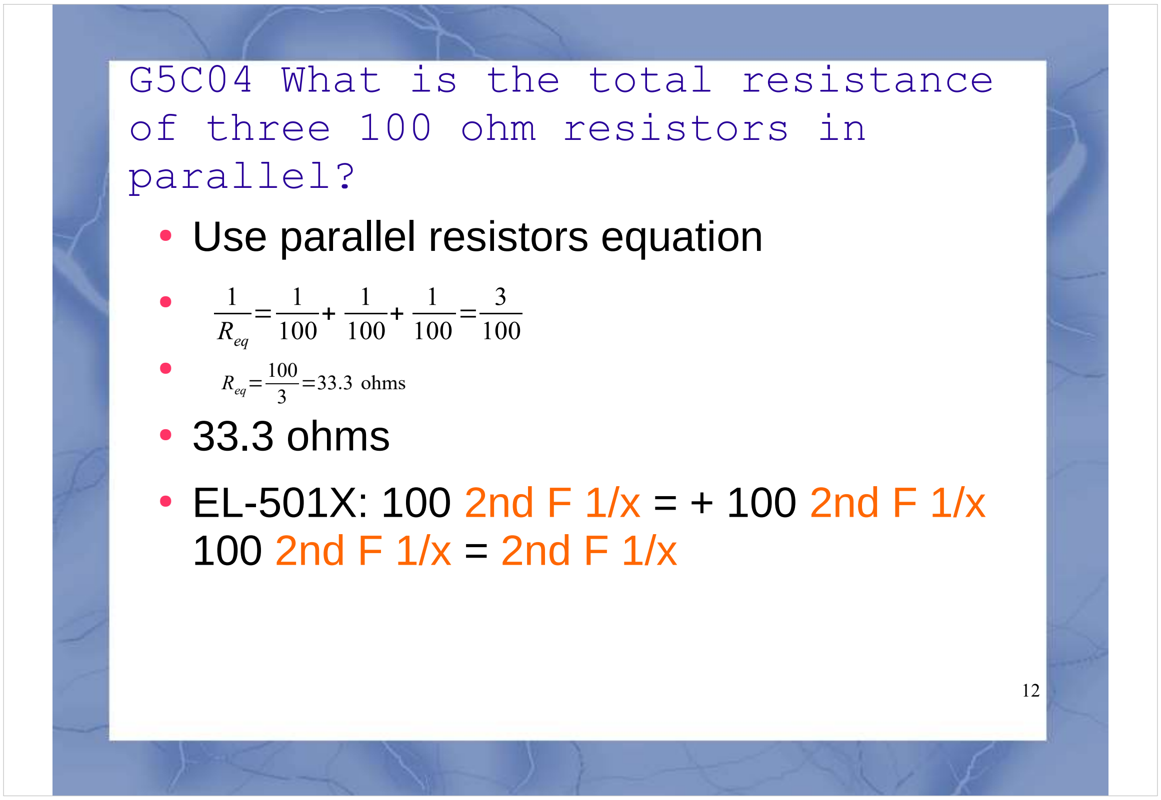
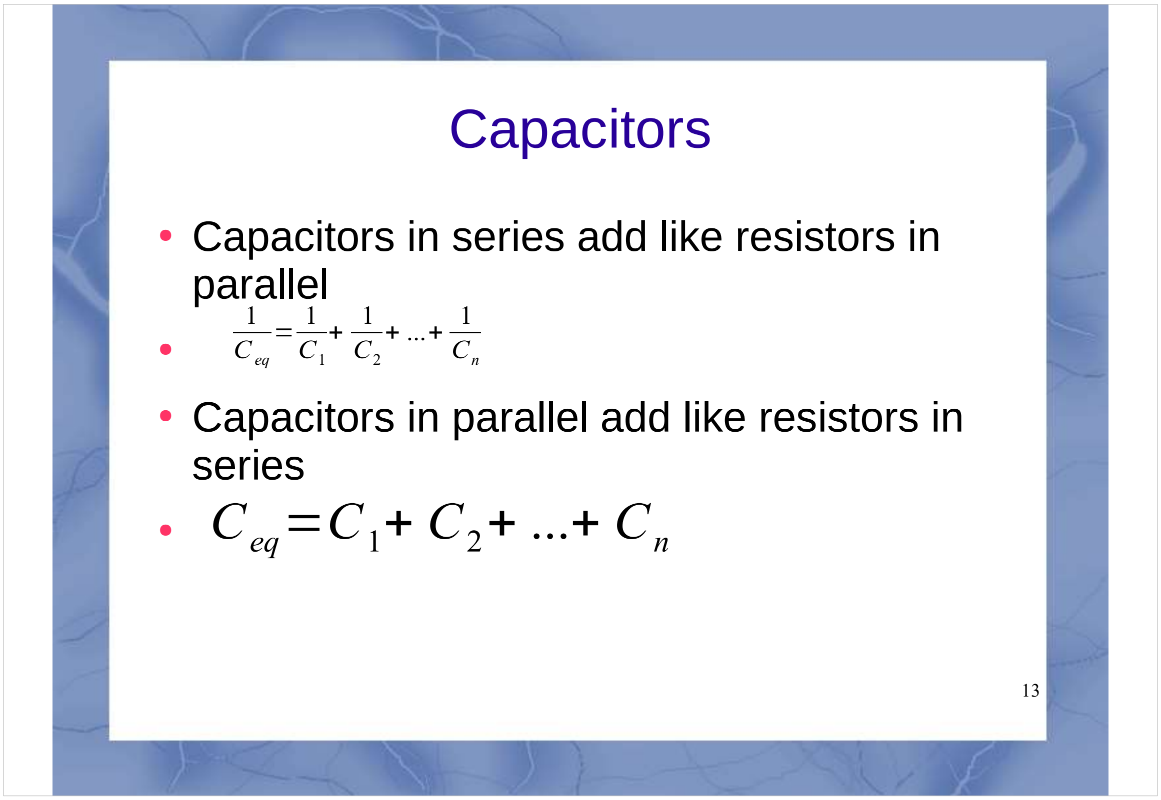
Resistors amy be connected in series (end-to-end) or in parallel (side-by-side). They may also be connected in parallel and series combinations but not on this exam. Just add the values when in series to find the equivalent resistance. And add the reciprocals (1 over values) to find the reciprocal of the resistance when resistors are in parallel. The take the reciprocal of the results to find the equivalent resistance.



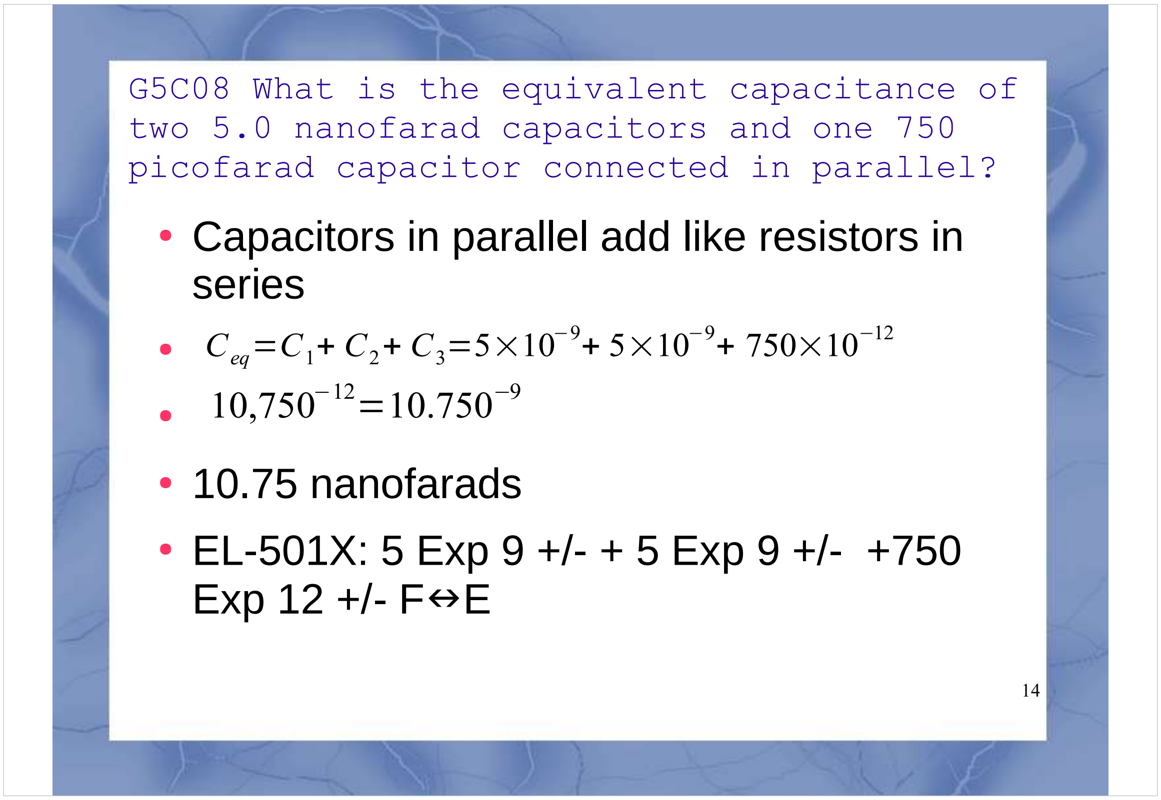
Adding a resistor in parallel will always reduce the equivalent resistance. Add adding a resistance will always increase the equivalent resistance. There for this problem you must add the resistance in series with the existing resistance.



You can use the equation and run the numbers. Or you can note that three identical resistors in parallel result in the intermediate term of R/3.

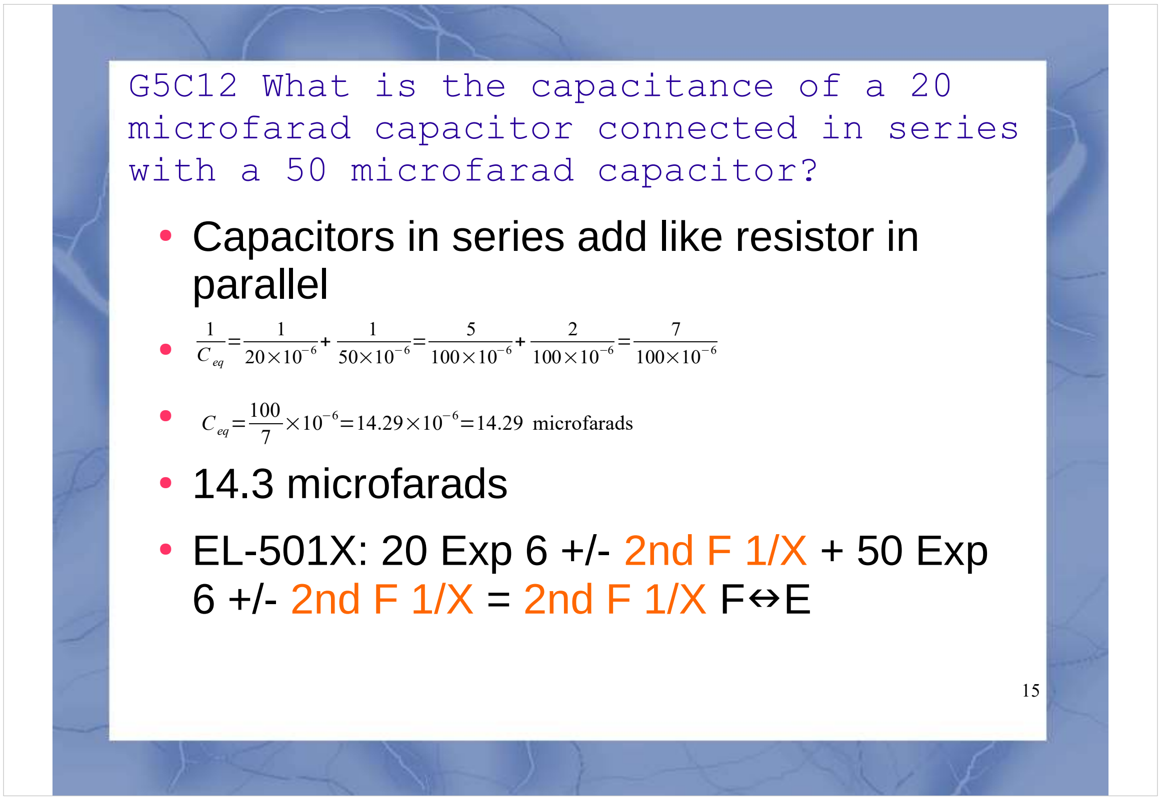


Capacitors act different than resistors. The relationships are “capacitors in series add as resistors in parallel” and “capacitors in parallel add as resistors in series”. This is derived from the fact that $C=\frac{\text{Area}}{\epsilon\times\text{distance}}$ for a physical capacitor. When in series you are effectively increase the distance between plates and the reciprocal relationship holds. When placing the capacitors in parallel you are effectively increasing the area.



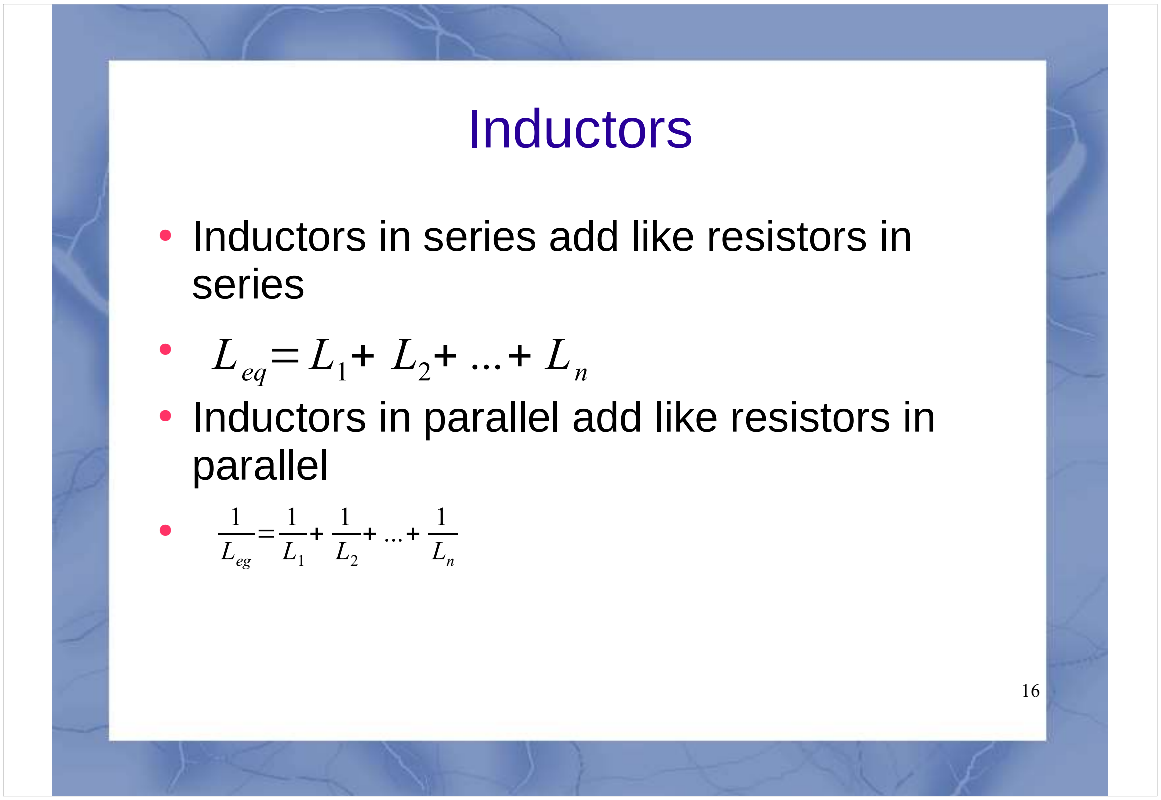
The answers are all in nanofarads. Therefore convert all quantities to nanofarads and apply the correct formula. 1 nanofarad = 1,000 picofarads or 0.750 (three-quarters) nanofarads = 750 picofarads.

Now apply the the formula for capacitors in parallel (resistors in series).

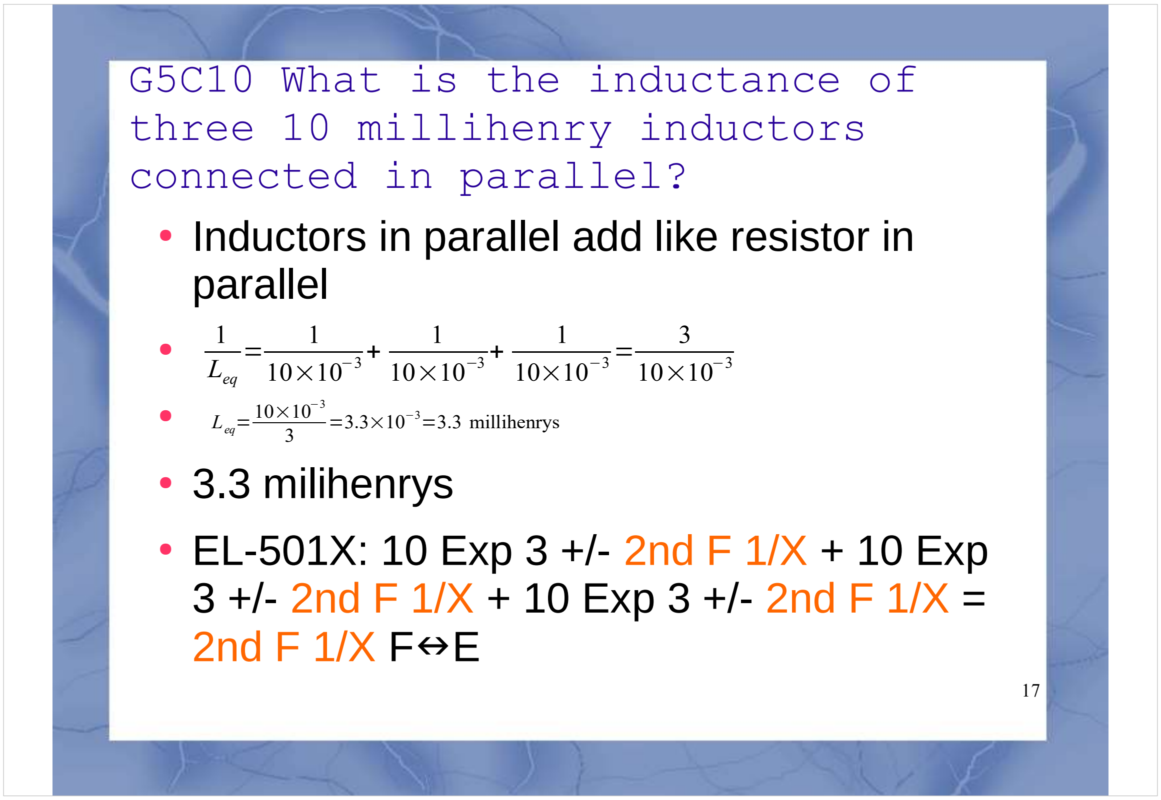


The answers are in microfarads and the values in the problem are also in microfarads. Therefore no magnitude conversions must be made.

Use the relationship for capacitors in series (resistors in parallel) which is the reciprocal relationship. Don’t to invert the answer to find the equivalent capacitance. Electrical elastance is the inverse of capacitance.



Inductors in series or parallel act as resistors in series and parallel. Therefore inductors in series add and inductors in parallel add as the reciprocal to yield reciprocal of the equivalent inductance. The reciprocal of inductance is called electrical reluctance (deprecated).



All three inductors are in units of millihenry so no scaling is required. Now take the reciprocal of all three and add. Then take the reciprocal of the result to find the equivalent inductance. Or use the concept of three resistors in parallel have the equivalent resistance of 1/3. Therefore since resistors and inductors have the same relationships, 10 millihenry inductors in parallel are 10/3 or 3.33 milihenry.

G5C11 What is the inductance of a 20 millihenry inductor connected in series with a 50 millihenry inductor?

- Inductors in series add like resistors in series
- $L_{eq} = 20\times10^{-3} + 50\times10^{-3} = 70\times10^{-3} = 70 \text{ milihenrys}'$
- 70 milihenrys
- EL-501X: 20 Exp 3 +/- + 50 Exp 3 +/- = F⇔E

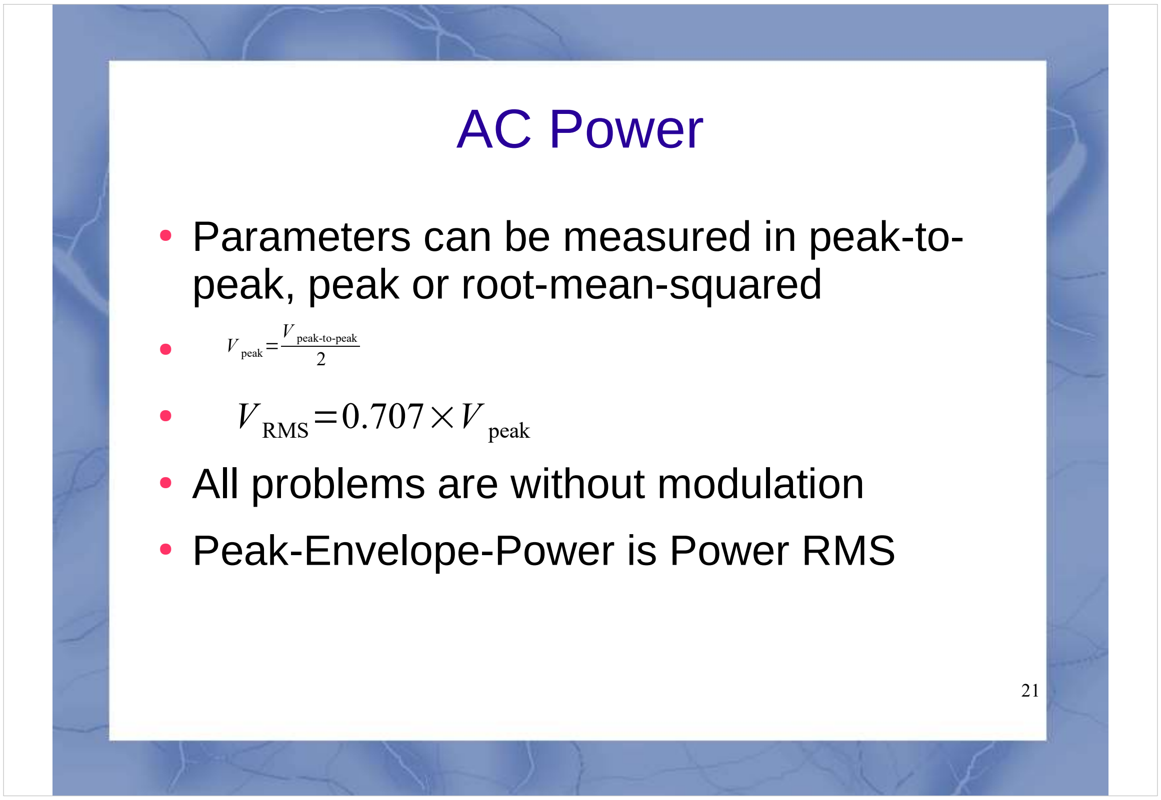
Inductors in seriers act as resistors in series. Since both inductances are in the units of millihenery, just add the values.

Transformers

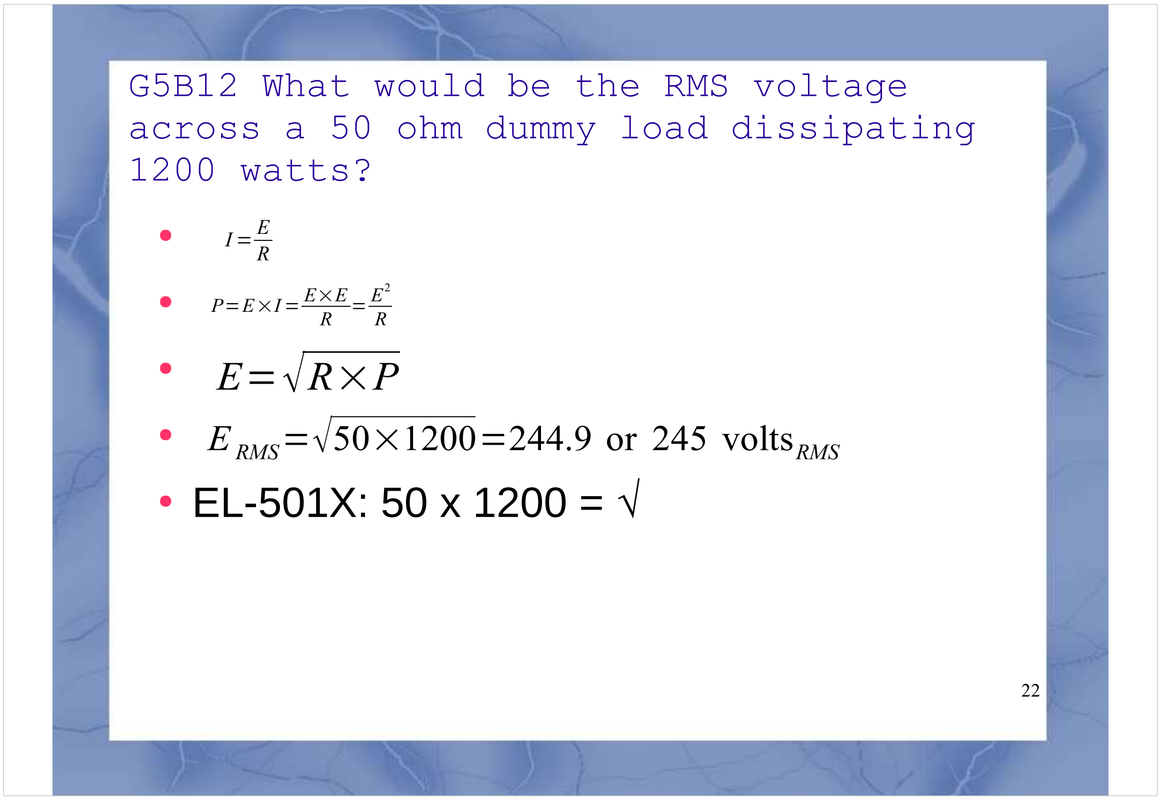
- On exam used for impedance matching
- $Z_2 = (\frac{N_2}{N_1})^2 \times Z_1$
- Also used for step-up or step-down transformer in real life
- $E_2 = \frac{N_2}{N_1} \times E_1$

G5C07 What is the turns ratio of a transformer used to match an audio amplifier having 600 ohm output impedance to a speaker having 4 ohm impedance?

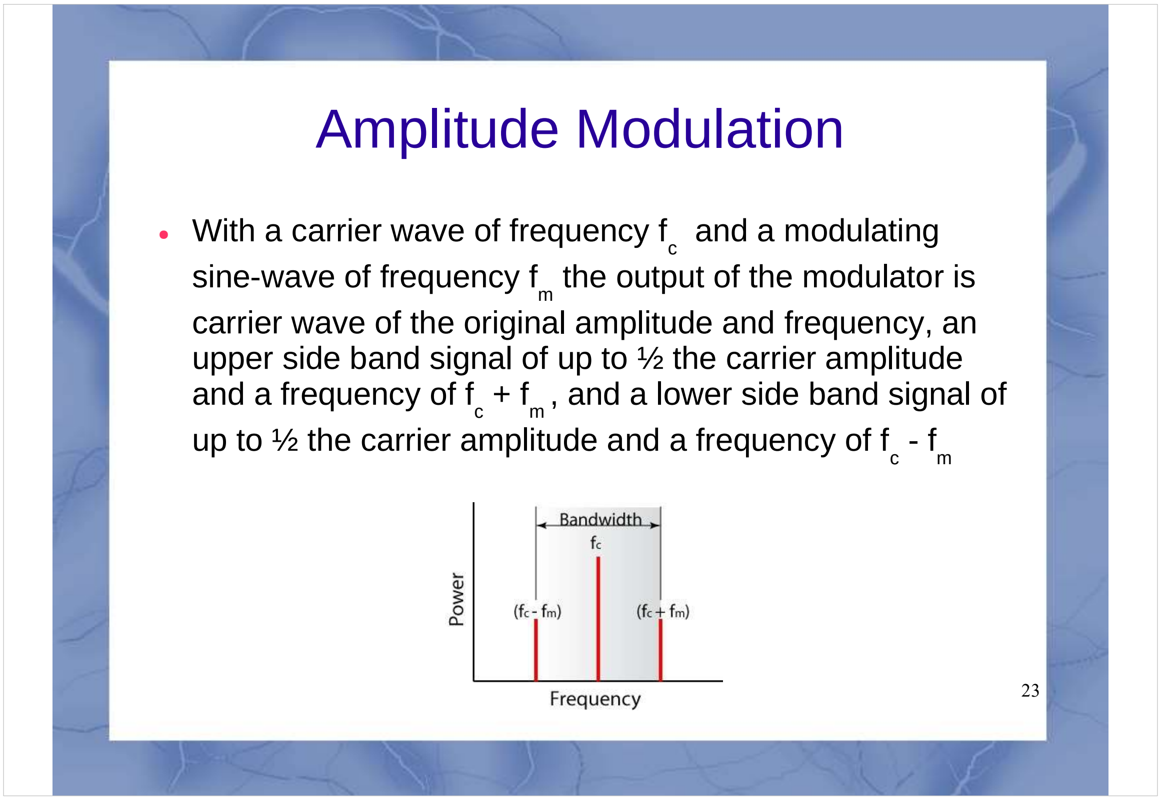
- From Maximum Power Transfer Theorem we want the 600 ohm output of amplifier to match 600 ohm input to trans former with 4 ohm load
- $Z_{in} = (\frac{N_2}{N_1})^2 \times Z_{spkr}$
- $600 = (\frac{N_2}{N_1})^2 \times 4$
- $\frac{N_2}{N_1} = \sqrt{\frac{600}{4}} = 12.2$
- 12.2 to 1
- EL-501X: 600 ÷ 4 = √



AC power is related to DC power by the effective value relationship or RMS (root-mean-squared). That is to say an RMS current in a resistor duces the same power loss as the DC current of the same magnitude. 1 amp RMS of AC current in a 2 ohm resistor dissipates 2 watts of power. In a similar manner 1 amp DC current in a 2 ohm resistor also dissipates 2 watts. V_{RMS} = V_{peak}/square-root of 2 or 0.707 x V_{peak}.



We have ohms (think Ohm's Law) and power (think Joule's Law). P = I x E and we want volts given power. Symbolically solve for the current, I, in Ohm's Law and substitute into Joule's Law. The result is $P = E^2/R$. Make the substitutions and solve for E.

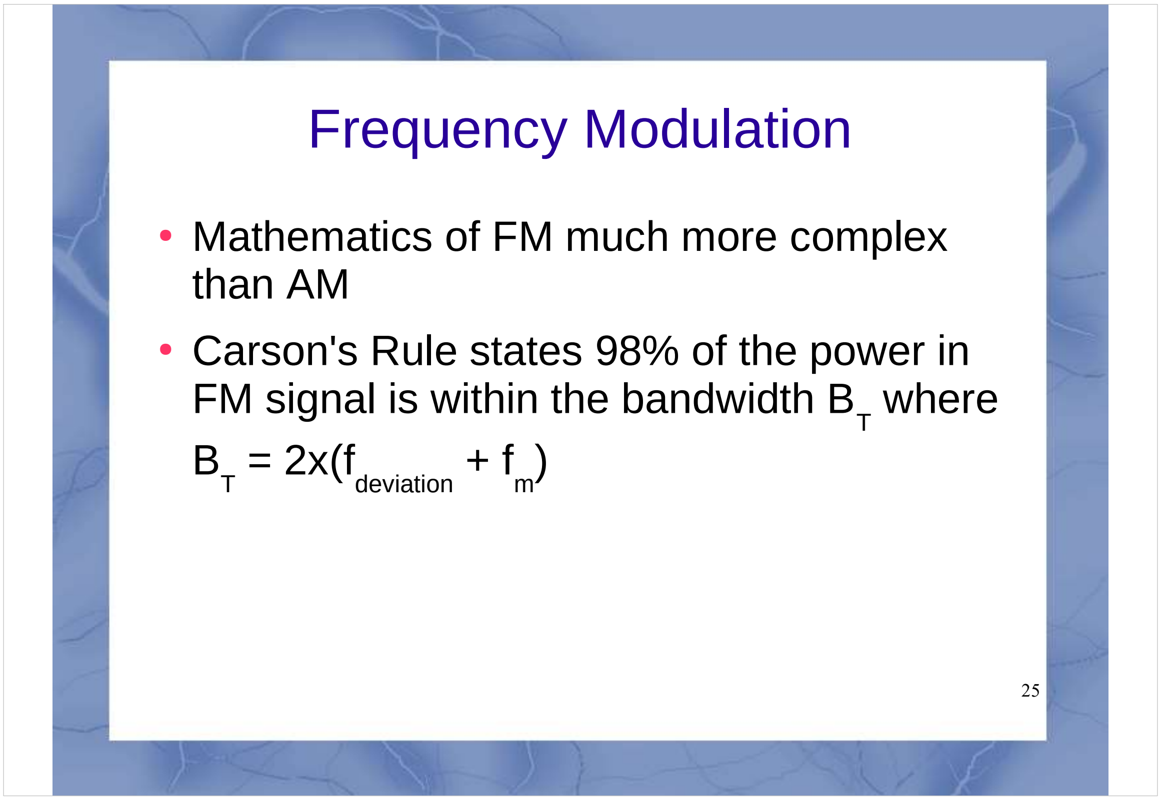


AM or amplitude modulation has the lower-sideband, carrier and upper-sideband. The carrier or f_c comes from the local oscillator. The modulation frequency or f_m comes from the audio source. When f_c and f_m are passed though a multiplier (AM mixer) trigonometry tells use that we get the sum $(f_c + f_m)$ or upper-sideband and the difference $(f_c - f_m)$ or lower-sideband.

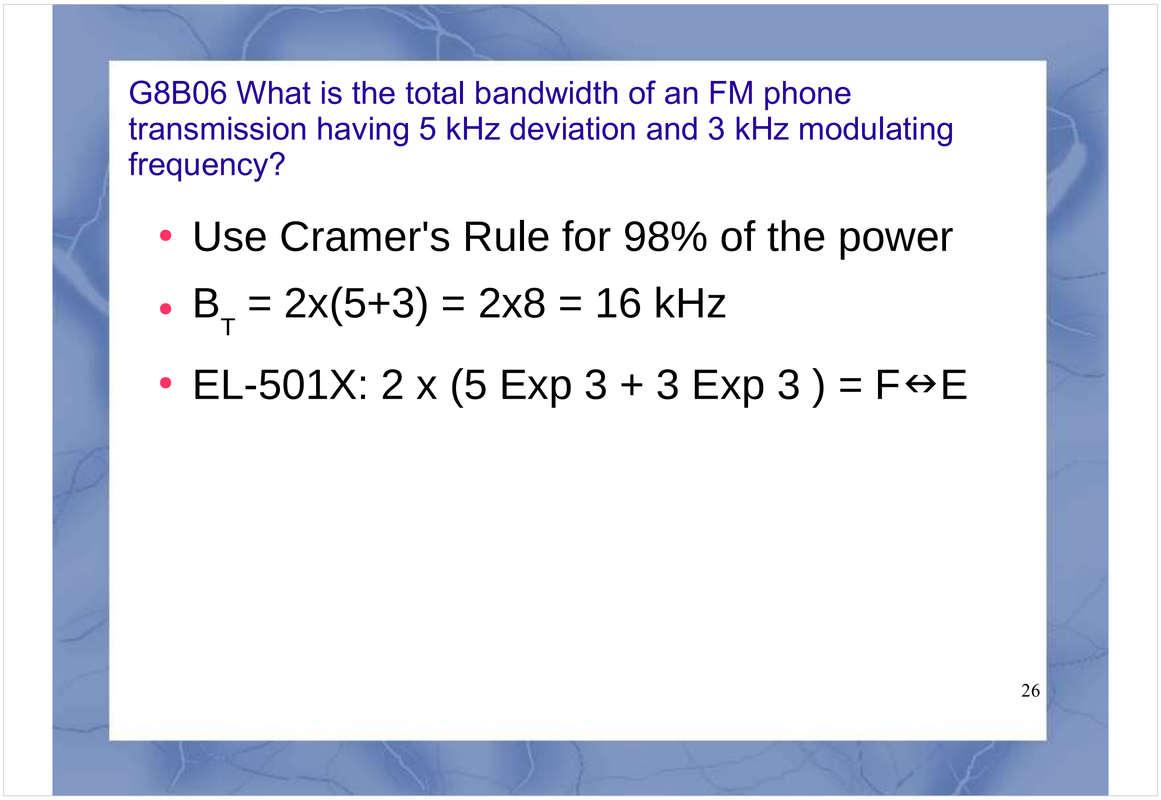
G4D08 What frequency range is occupied by a 3 kHz LSB signal when the displayed carrier frequency is set to 7.178 MHz?

- The displayed frequency is the virtual carrier frequency, f_c.
- f_{lsb} = 3 kHz = 0.003 MHz
- Since lower side band f_c - f_{lsb}=7.175 MHz to f_c = 7.178 MHz
- EL-501X: 7.178 Exp 6 – 3 Exp 3 = F⇔E

Lower-sideband if fc-fm. The fm = 3kHz or 0.003 MHz. Therefore fc-fm = 7.178 – 0.003 = 7.175 MHz. The frequency range is 7.175 MHz to 7.178 MHz.



AM analysis only requires trigonometry, FM analysis requires an understanding of Bessel functions at a minimum. Therefore FM analysis is often done using rules of thumb and approximations. One approximation is Carson’s Bandwidth Rule. This rule should only be used with rather smooth wave forms such as voice and not square waves such as some digital modes.



Use Carson’s Bandwidth Rule of add and double.

Standing Wave Ratio

- Defined as: $SWR = \dfrac{1 + \sqrt{\dfrac{P_r}{P_f}}}{1 - \sqrt{\dfrac{P_r}{P_f}}}$
- For problems on exam use $SWR = \dfrac{Z_{\text{Largest}}}{Z_{\text{Smallest}}}$

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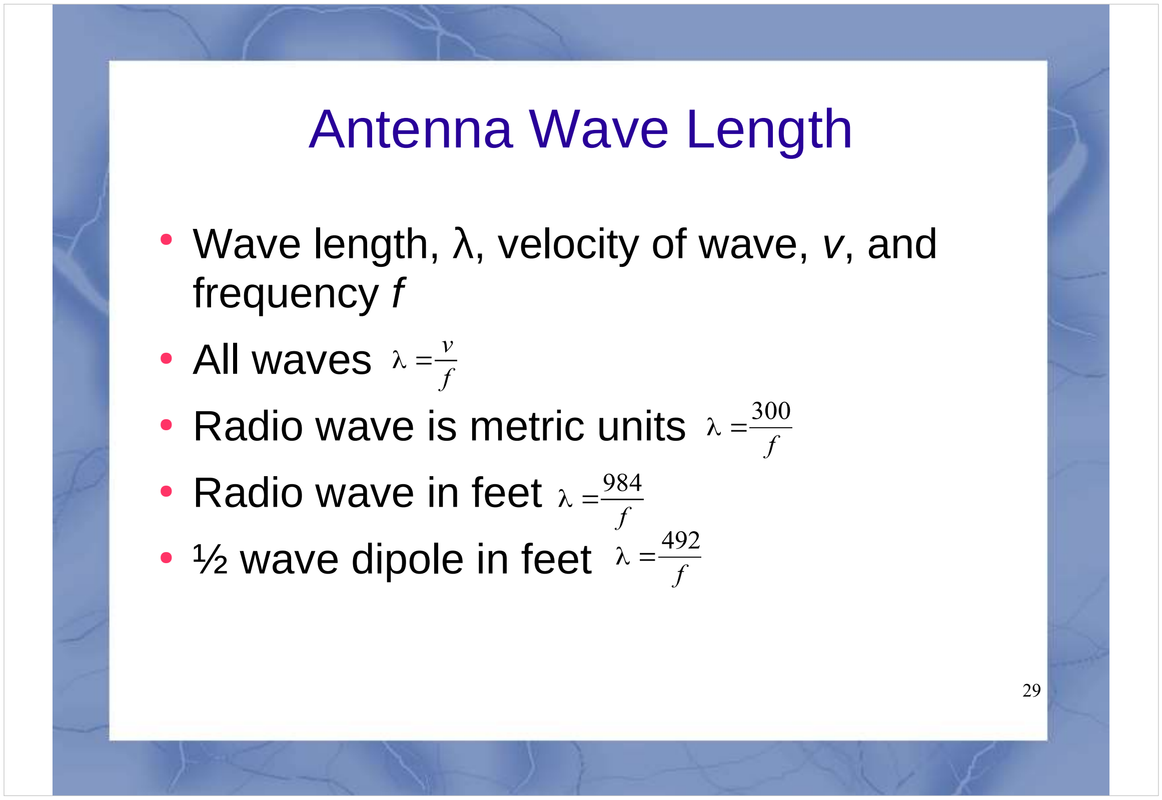
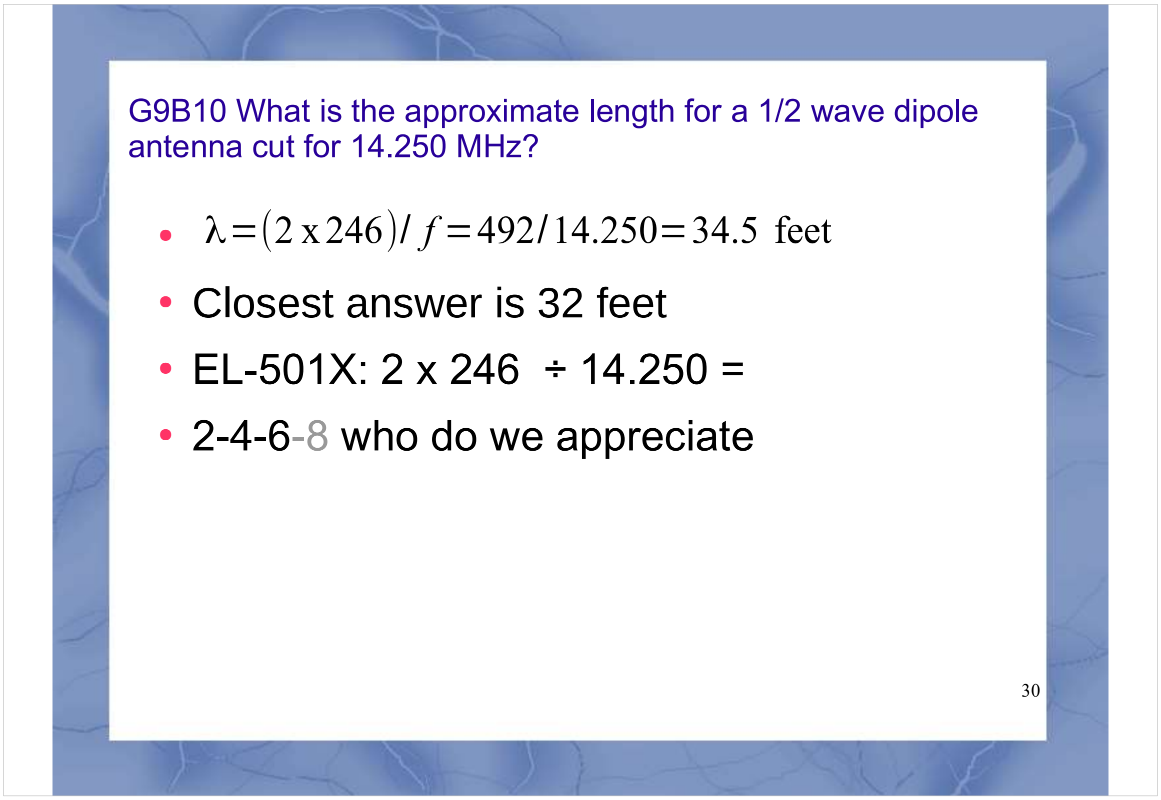
The top formula is the defining formula The bottom formula only apples for for a purely resistive load. Since the ratio is always a positive number greater or equal to 1 to 1 use the larger number over the smaller number. Such as 1 to 1 or 4 to 1 etc. In the element 3 question pool all problems have a purely resistive load and none require the top formula.

G9A09 What standing wave ratio will result when connecting a 50 ohm feed line to a non-reactive load having 200 ohm impedance?

- $\mathrm{SWR} = Z_{\mathrm{Largest}} / Z_{\mathrm{Smallest}} = 200/50 = 4$
- SWR is 4:1
- EL-501X: 200 ÷ 50 =



For US hams we design antenna in feet. Therfore the equation changes from $\lambda = \frac{300}{f}$ to $\lambda = \frac{948}{f}$ or for a 1/2-wave antenna $\lambda = \frac{492}{f}$ since 948/2 = 492. What would be the formula for a 5/8 wave antenna?



Either remember the number 492 or convert 300 million meters per second to 984 million feet per second using 2.54 cm per inch or some other ratio you remember. Not for a que=arter wave the number 246 so some remember 2468 who do we appreciate. You drop the 8 and multiply by 2 for half wave antenna elements.