A **band pass filter** is a circuit that passes frequencies within a certain range, or band. Frequencies above and below this band are attenuated.
For the ideal frequency response shown, the range of frequencies passed by the filter is the passband.
The two frequency ranges attenuated by the filter are the upper and lower stopbands.
The midpoint of the passband is the center frequency ($f_0$).
The corner frequency at the leading edge of the passband is the **lower cutoff frequency** ($f_1$).

The corner frequency at the trailing edge of the passband is the

a. lower cutoff frequency.
b. upper cutoff frequency.
c. center frequency.
These are the response curves of ideal band pass, low pass, and high pass filters.
The portion of the band pass curve now highlighted resembles the response of an ideal
a. high pass filter.
b. low pass filter.
The highlighted portion of the band pass curve is similar to the response of an ideal

a. high pass filter.

b. low pass filter.
In practice, a band pass filter is sometimes designed using a low pass filter in combination with a high pass filter.
This is the frequency response of a practical band pass filter.
The lower cutoff frequency ($f_1$) is the point below the center frequency ($f_0$) at which the output is 3 dB below the maximum gain. The highlighted point is the **lower 3 dB down point**.
The **upper cutoff frequency** \( (f_2) \) is the point above \( f_0 \) at which the output is 3 dB below the maximum gain. The point now highlighted is the **upper 3 dB down point**.
The passband is the range of frequencies between $f_1$ and $f_2$. Which expression defines the bandwidth (BW) of the passband?

a. $BW = f_2 - f_0$

b. $BW = f_2 - f_1$

c. $BW = f_0 - f_1$
The stop band(s) is(are) from
a. 0 to
b. $f_2$ and above.
c. Both of the above.
The center frequency ($f_0$) occurs at the

a. upper 3 dB down point.

b. lower 3 dB down point.

c. midpoint of the passband.
Band pass filters are classified as either narrow-band pass filters or wide-band pass filters.

If the bandwidth is less than or equal to 10% of the center frequency ($f_0$), the filter is a narrow-band pass type.

If the bandwidth is greater than 10% of $f_0$, the filter is a wide-band pass type.
The *selectivity* of a band pass filter is its ability to pick out a narrow range of frequencies from a relatively wide frequency spectrum.
Selectivity can be expressed by a band pass filter's quality factor, or $Q$-factor, defined by the equation $Q = f_0/BW$. 
A narrow-bandwidth, or highly selective, filter is a high-Q filter (curve B).

A wide-bandwidth filter is a low-Q filter (curve A).
A high-Q filter has a minimum Q of 10 \( \left[ f_0/BW = f_0/(0.1 \times f_0) = 10 \right] \). Therefore, high Q filters have Q factors of 10 and up, while low-Q filters have Q factors below 10.
If a bandpass filter has a bandwidth of 500 Hz and a 10 kHz center frequency \( f_0 \), what is its Q factor?

\[
Q = 20
\]

Correct. The Q factor is 20.
Q = 20

Would this filter be classified a high-Q or low-Q filter?

a. high-Q
b. low-Q
If a band pass filter has a gain of 1 at $f_0$ and a 1 $V_{pk-pk}$ sine wave input with a frequency equal to $f_1$, what is the output voltage?

$$V_o (f_1) = V_{pk-pk}$$
If a band pass filter has a gain of 1 at $f_0$ and a 1 $V_{pk-pk}$ sine wave input with a frequency equal to $f_1$, what is the output voltage?

$$V_o (f_1) = 0.707 \times V_{pk-pk}$$

Correct. $f_1$ occurs at 3 dB down, so the output voltage is 70.7% of the voltage at $f_0$. 
8. How can you determine the output voltage at the upper and lower cutoff frequencies?
   
   a. Multiply the voltage at $f_0$ by 0.5.
   
   b. Multiply the voltage at $f_0$ by 0.707.
   
   c. Take 10% above and below the voltage at $f_0$. 
14. Calculate the bandwidth of the circuit.

\[ BW = \text{kHz} \]
14. Calculate the bandwidth of the circuit.

$$BW = 5.8 \text{ kHz}$$

Correct. Your calculation is within tolerance.
15. What is the Q factor of the circuit?

\[ Q = \]
15. What is the Q factor of the circuit?

\[ Q = 2 \]

Correct. Your calculation is within tolerance.
16. Is this circuit a narrow-band pass or wide-band pass filter?
   a. narrow-band pass
   b. wide-band pass
16. Is this circuit a narrow-band pass or wide-band pass filter?

a. narrow-band pass  
Correct. A wide-band pass filter has a Q factor less than 10.

b. wide-band pass
- A band pass filter passes a specific range of frequencies and attenuates frequencies above and below this range.

- A band pass filter's passband is between its upper and lower cutoff frequencies.

- The center frequency of a band pass filter is about midway between its upper and lower cutoff frequencies, or in the center of the passband.
- A band pass filter has maximum gain at the center frequency and 
  -3 dB attenuation at the upper and lower cutoff frequencies.

- The selectivity of a band pass filter is determined by its Q factor, 
  which is the ratio of its center frequency to its bandwidth.
1. If you know a band pass filter's center frequency and lower cutoff frequency, how can you determine the upper cutoff frequency?

a. by doubling
b. by doubling $f_0$
c. by subtracting $f_1$ from $f_0$ and adding the result to
d. cannot be determined
1. If you know a band pass filter's center frequency and lower cutoff frequency, how can you determine the upper cutoff frequency?

a. by doubling  
b. by doubling $f_0$  
c. by subtracting $f_1$ from $f_0$ and adding the result to  
d. cannot be determined

Correct. The difference between $f_1$ and $f_0$ is the same as the difference between $f_0$ and $f_2$. 
3. What is the Q factor of a band pass filter with the characteristics shown?

a. 2  
 b. 3  
 c. 6  
 d. 12
3. What is the Q factor of a band pass filter with the characteristics shown?

a. 2  

b. 3  

c. 6  

d. 12  

Correct. $f_0/BW = 2$
4. You can classify this filter as a

a. narrow-band pass filter.    c. high-Q filter.
b. wide-band pass filter.      d. None of the above.
4. You can classify this filter as a

a. narrow-band pass filter.  
b. wide-band pass filter.  
c. high-Q filter.  
d. None of the above.

Correct. The Q factor is less than 10.
5. In order to find a band pass filter's center frequency with an oscilloscope, you can increase the input frequency until the output voltage is at

a. 70.7% of its maximum level. 

b. its minimum level.

c. its maximum level.

d. 1 V_{pk-pk}.
5. In order to find a band pass filter's center frequency with an oscilloscope, you can increase the input frequency until the output voltage is at

a. 70.7% of its maximum level.  

b. its minimum level.  

c. its maximum level.  

d. 1 V_{pk-pk}.

Correct. The maximum voltage is at $f_0$. 
10. Adjust the TIME VARIABLE and trigger controls to get the waveforms shown. Make sure that 1 full cycle of the CH 1 (input) waveform covers 8 cm on the horizontal scale.

How many degrees of phase does 1 cm on the horizontal scale represent?

a. 36°
b. 45°
c. 90°
10. Adjust the TIME VARIABLE and trigger controls to get the waveforms shown. Make sure that 1 full cycle of the CH 1 (input) waveform covers 8 cm on the horizontal scale.

How many degrees of phase does 1 cm on the horizontal scale represent?

a. 36°  
Correct. If 360° equals 8 cm, then 1 cm equals 360/8, or 45°.

b. 45°

c. 90°
18. Adjust the TIME VARIABLE and trigger controls to get the waveforms shown. Make sure that 1 full cycle of the CH 1 (input) waveform covers 8 cm on the horizontal scale.

19. Measure the phase shift at $f_1$.

Phase shift ($f_1$) = ______ degrees
18. Adjust the TIME VARIABLE and trigger controls to get the waveforms shown. Make sure that 1 full cycle of the CH 1 (input) waveform covers 8 cm on the horizontal scale.

19. Measure the phase shift at $f_1$.

Phase shift ($f_1$) = -135° degrees

Correct. The phase shift is about -135°.
23. Measure the phase shift at $f_2$.

Phase shift ($f_2$) = ______ degrees
23. Measure the phase shift at $f_2$.

Phase shift ($f_2$) = \boxed{-225} degrees

Correct. Your measurement is within the accepted tolerance.