14.42

$$v_a = -4.5\frac{R_f}{R_0}[2^3b_3 + 2^2b_2 + 2^1b_1 + b_0]$$

a) $v_a = -4.5(\frac{1}{15})(12) = -3.6$ V

b) $(v_a)_{max} = -4.5(\frac{1}{15})(15) = -4.5$ V

c) $\delta v = 4.5(\frac{1}{15}) = 0.3$ V

d) $$n \ge \frac{\log(\frac{|(v_a)_{max} - (v_a)_{min}|}{\delta v} + 1)}{\log 2}$$

or $n \ge 7.82$

Therefore, we choose n= 8.

14.44

This circuit is just a summing amplifier, with

$$v_O = -\frac{R_2}{R_1}b_3V - \frac{R_2}{2R_1}b_2V - \frac{R_2}{4R_1}b_1V - \frac{R_2}{8R_1}b_0V$$

$$= -\frac{R_2V}{R_1}\left(b_3 + \frac{b_2}{2} + \frac{b_1}{4} + \frac{b_0}{8}\right)$$

$$= -\frac{R_2V}{8R_1}(8b_3 + 4b_2 + 2b_1 + b_0)$$

14.46

For the circuit of Figure P14.13, $R_0 = 1$ kΩ and n = 4.

Therefore, $(v_a)_{max} = -10$ V

and $-10 = -5\frac{R_f}{1000}(15)$

or $R_f = 133.3$ Ω

14.49

a) $v_a = -10(\frac{1}{4095})(345) = -0.8425$ V

b) $(v_a)_{max} = -10(\frac{1}{4095})(4095) = -10$ V

c) $\delta v = 10(\frac{1}{4095}) = 2.44$ mV

d) $$n \ge \frac{\log(\frac{|(v_a)_{max} - (v_a)_{min}|}{\delta v} + 1)}{\log 2}$$

or $n \ge 14.288$

Therefore, we choose a 15-bit ADC.

14.52

$$n \ge \frac{\log(\frac{30}{0.01} + 1)}{\log 2} = 11.55$$

Choose n = 12.

14.56

(a) resolution $= 2^{-3} \times 10V = 1.25V$

(b) resolution $= 2^{-8} \times 10V = 39.0625mV$

(c) more bits ⇒ better resolution

14.64

(a) 5% ⇒ $2^{-n} \le 0.05$ ⇒ $n = 5$

(b) 2% ⇒ $2^{-n} \le 0.02$ ⇒ $n = 6$

(c) 1% ⇒ $2^{-n} \le 0.01$ ⇒ $n = 7$

14.70

(a) Define $V_2 = \frac{R_1}{R_2 + R_1} V$ as the voltage at the invertig input of the op-amp. Then:

When $V_{in} > V_2$ the output of the op-amp will be positive and the green LED will turn on (*go*).

When $V_{in} < V_2$ the output of the op-amp will be negative and the red LED will turn on (*no go*)

(b) For this design, $V_2 = 5V$ and $V = 15V$.

$$\therefore \frac{R_1}{R_2 + R_1} 15V = 5V$$

$$\Rightarrow \frac{R_1}{R_2 + R_1} = \frac{1}{3}$$

or $\frac{R_2}{R_1} + 1 = 3$

$$\Rightarrow \frac{R_2}{R_1} = 2$$

Choose $R_1 = 10k\Omega$ and $R_2 = 20k\Omega$ to complete the design