

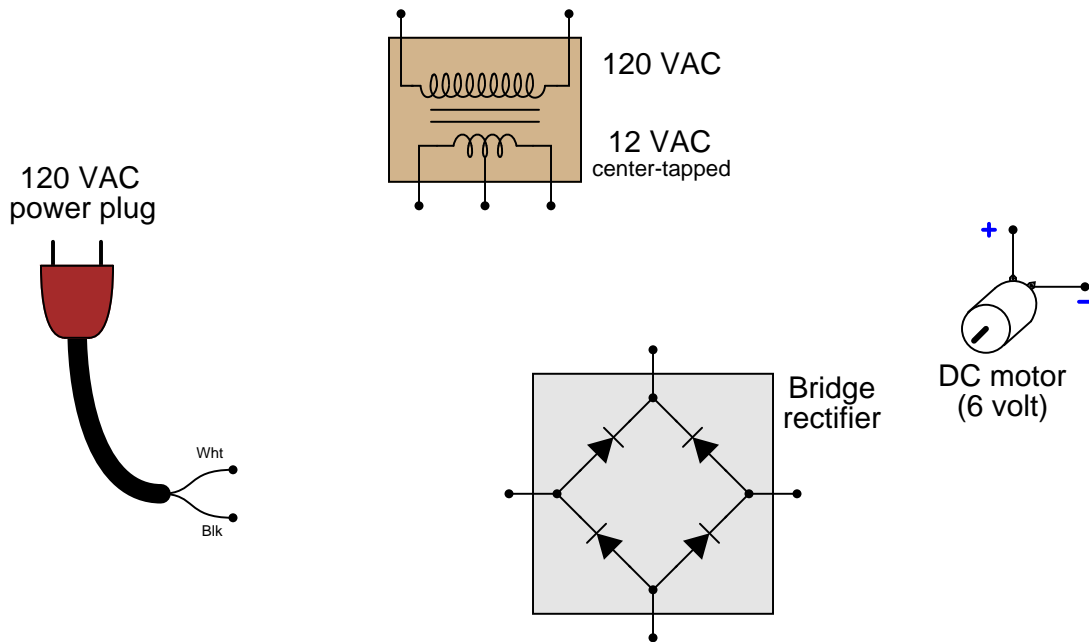
NAME:

#	Question type	1st attempt	2nd attempt
1	Circuit sketching		
2-3	DC circuits		
4-5	Mathematics		
6	Circuit fault analysis		
7-8	AC and opamp circuits		
9-10	Relay and digital circuits		
--	Fractional score / Percentage score	Score = /	Score = %

No credit will be given for mathematical answers unless your work is shown!

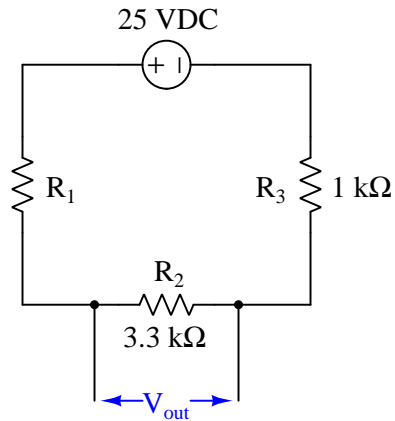
(1) Circuit sketching

Sketch wires connecting components together to form an AC-to-DC power supply circuit suitable for powering a 6-volt electric motor:



(2) DC circuit analysis

Calculate the necessary value for resistor R_1 in this circuit to provide an output voltage (V_{out}) of 8.1 volts:

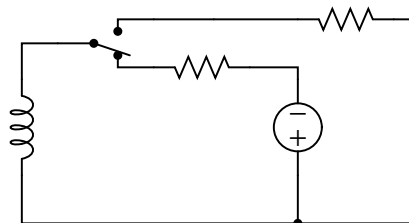


$$R_1 =$$

Also, mark the polarity of V_{out} with “+” and “-” symbols.

(3) DC capacitor/inductor circuit analysis

Suppose the switch has been left in the “down” position (as shown in the diagram) for a long time, and then is suddenly toggled to the “up” position:



Moments after the switch transitions to its new state, sketch the following on the schematic diagram:

- Voltage polarity across the inductor (+ and - symbols)
- Voltage polarity across the current-carrying resistor (+ and - symbols)
- Direction of current through the resistor (arrow pointing in the direction of conventional flow)

(4) Algebraic manipulation

The failure rate (λ) for a well-maintained batch of devices may be calculated using the following formula, based on the total number of devices (N_o) in the batch, number of failed devices (N_f) during the test period, and the duration of the test (t):

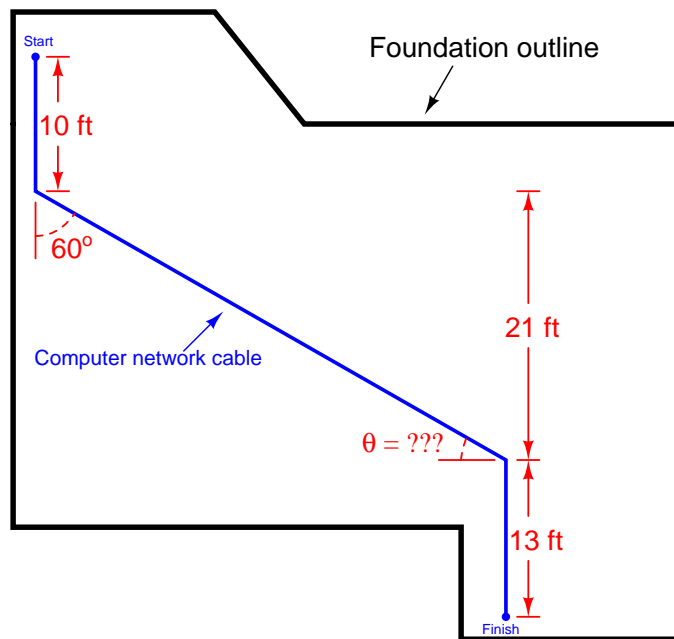
$$\lambda = \frac{N_f}{t} \frac{1}{N_o}$$

Algebraically manipulate this formula to solve for N_o :

$$N_o =$$

(5) Trigonometry

A technician needs to calculate the appropriate length of cable to install computer network wiring in the foundation of a new building. The dimensions shown on the foundation blueprint are all the technician has to work with:



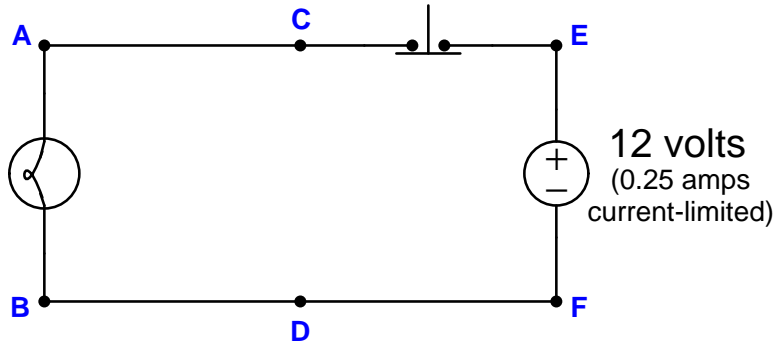
Calculate the total cable length necessary for this job, as well as the value of the unknown angle shown on the blueprint.

Total cable length =

$\theta =$

(6) Circuit fault analysis

Suppose the lamp refuses to light up regardless if the pushbutton switch is pressed or not. A voltmeter registers 12 volts between test points **E** and **B** in the circuit while the pushbutton is pressed:

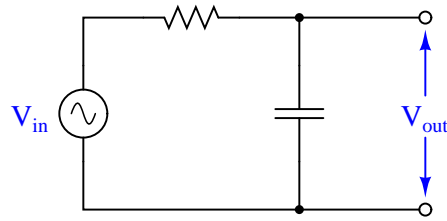


Identify the likelihood of each specified fault for this circuit. Consider each fault one at a time (i.e. no coincidental faults), determining whether or not each fault could independently account for *all* measurements and symptoms in this circuit.

Fault	Possible	Impossible
Open wire between A and C		
Open wire between B and D		
Open wire between D and F		
Lamp failed open		
Switch failed open		
Lamp failed shorted		
Switch failed shorted		
Voltage source dead		

(7) AC circuit analysis

Identify the type of phase shift exhibited from input to output of the following circuit:

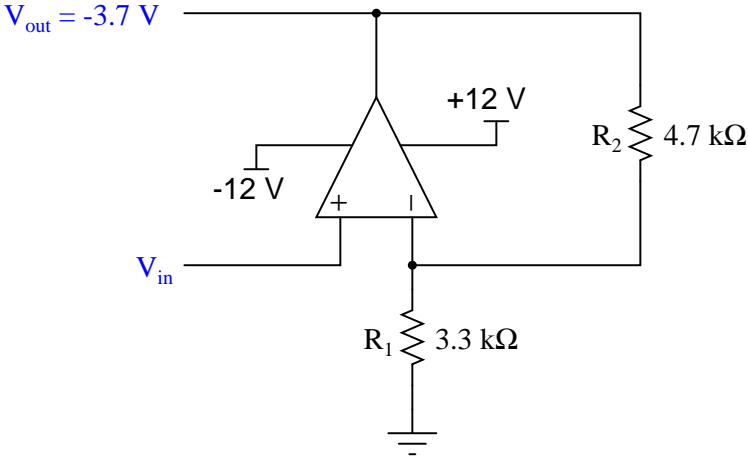


Next, identify the phase-shift behavior of this same circuit supposing the capacitor fails *shorted*. Place two check-marks in the table below to identify each phase-shifting characteristic (one check-mark identifying the healthy circuit's phase shift and another check-mark identifying the faulted circuit's phase shift):

Phase shift	Healthy circuit	Faulted circuit
V_{out} lags behind V_{in}		
V_{out} leads ahead of V_{in}		
V_{out} is in-phase with V_{in}		
V_{out} is zero (no output signal)		

(8) Opamp circuit analysis

Calculate the amount and direction of current through resistor R_2 in this opamp circuit, given the output voltage and resistor values shown. Assume the opamp is capable of “rail-to-rail” output voltage swings, and that the output voltage is specified in reference to ground. Be sure to sketch your current arrow in the direction of *conventional* flow:

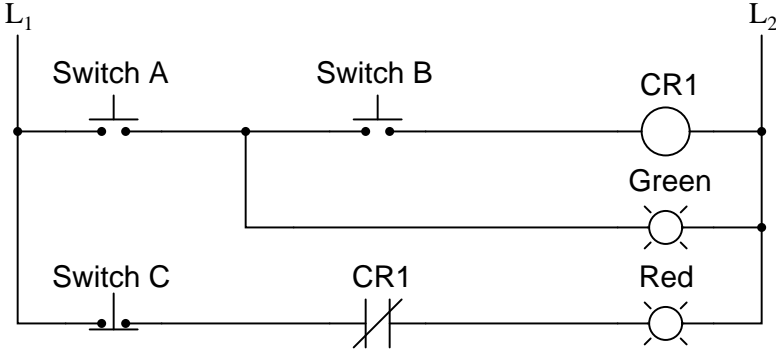


$I_{R2} =$

(9) Relay ladder logic circuit analysis

Assess the status of this relay circuit, given the following (simultaneous) switch actuation statuses:

- Switch A = *pressed*
- Switch B = *unpressed*
- Switch C = *unpressed*

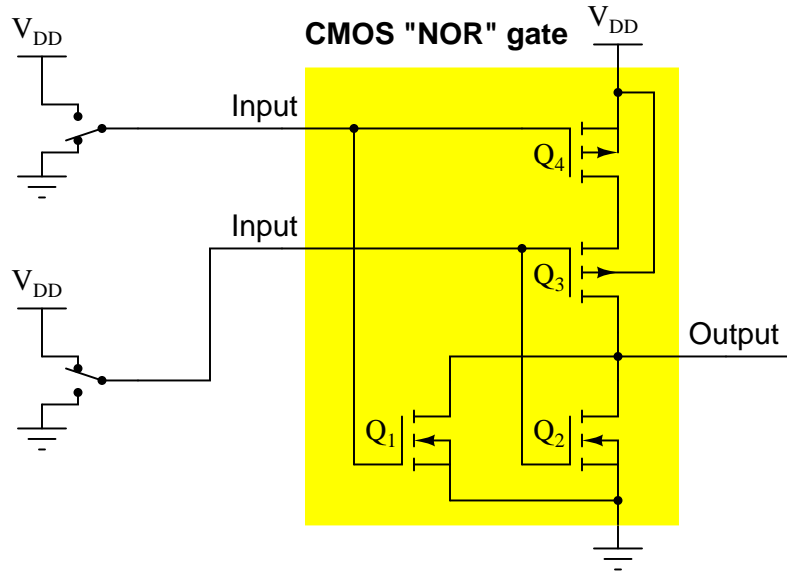


Now, check the appropriate cells in this table indicating whether each of the specified components is energized (powered) or de-energized (unpowered):

Component	Energized	De-energized
Red lamp		
Green lamp		
CR1 coil		

(10) Semiconductor digital circuit analysis

Determine the on/off state of the transistors within this CMOS “NOR” logic gate, given the input switch states shown in the diagram:



Place one check-mark in each row of the table, identifying the state of each transistor listed:

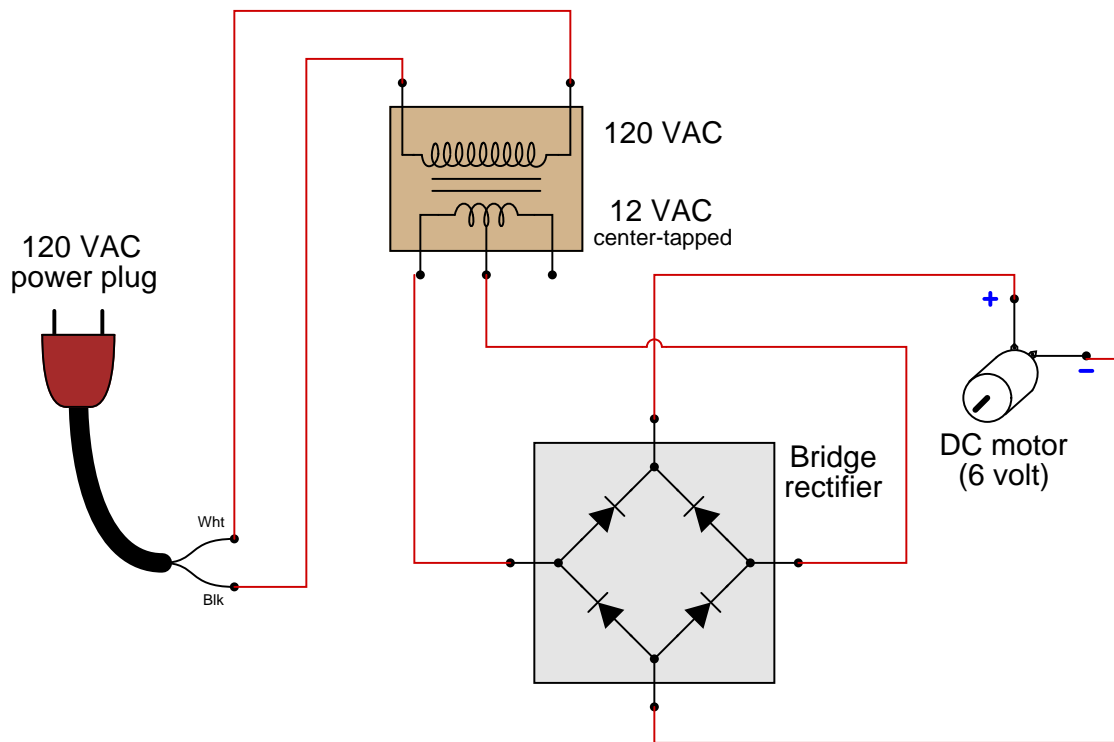
Transistor	On (conducting)	Off (non-conducting)
Q_1		
Q_2		
Q_3		
Q_4		

This page intentionally left blank

Answers

Answer 1

This is just one possible solution:

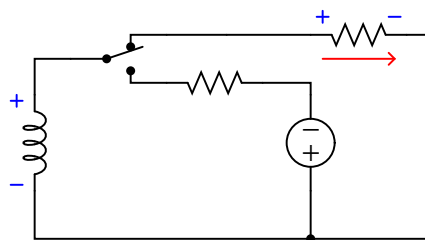


Answer 2

$$R_1 = 5.885 \text{ k}\Omega$$

V_{out} is positive on the left and negative on the right.

Answer 3



Answer 4

$$N_o = \frac{N_f}{t} \frac{1}{\lambda}$$

Answer 5

Total cable length = 65 ft

$$\theta = 30^\circ$$

Answer 6

Fault	Possible	Impossible
Open wire between A and C	✓	
Open wire between B and D		✓
Open wire between D and F		✓
Lamp failed open	✓	
Switch failed open	✓	
Lamp failed shorted	✓	
Switch failed shorted		✓
Voltage source dead		✓

Answer 7

Phase shift	Healthy circuit	Faulted circuit
V_{out} lags behind V_{in}	✓	
V_{out} leads ahead of V_{in}		
V_{out} is in-phase with V_{in}		
V_{out} is zero (no output signal)		✓

Answer 8

$$I_{R2} = 0.4625 \text{ mA (arrow pointing upwards)}$$

Answer 9

Component	Energized	De-energized
Red lamp	✓	
Green lamp	✓	
CR1 coil		✓

Answer 10

Transistor	On (conducting)	Off (non-conducting)
Q_1		✓
Q_2	✓	
Q_3		✓
Q_4	✓	
