1. What would you use a function generator for?
   a) Building circuits
   b) Controlling a voltage
   c) Measuring resistance
   d) Measuring voltage as a function of time
   e) Producing sine, square, and triangle waves

2. The equation governing the output voltage of a pot is Vout = R1/(R1 + R2)*Vin. Assuming you are controlling the angle of the shaft (theta), and knowing that R1 + R2 = Rtot = constant and R2 = k*theta with k constant, which of the following is true:
   a) Vout can exceed Vin.
   b) Vout varies linearly with the angle of the shaft (theta).
   c) Vout satisfies Vout = c*Vin, where c is a constant specific to the potentiometer.
   d) R2 can be negative.
   e) None of the other answers

For questions 3 and 4 assume that you measure a wave using the oscilloscope and characterize the wave as:

$$V(t) = 1.5sin(2\pi t)$$

3. What is the frequency of the wave?
   a) 1Hz
   b) 10 rpm
   c) $1\frac{radian}{sec}$
   d) 60Hz
   e) None of the above

4. What is the DC offset of the wave?
   a) 1.5V
   b) 4.5V
   c) 0V
   d) 3V
   e) None of the above

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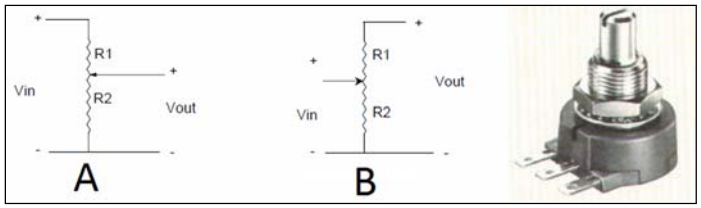
5. Shown are two ways to wire a pot. One is incorrect. What is the amount of current through R2 for the correct and incorrect ways, respectively?



   a) Vin/R1 and Vout/R2
   b) Vin/(R1+R2) and Vin/R2
   c) Vout/R2 and Vin/R2
   d) Vin/(R1+R2) and Vout/R2
   e) None of the above

6. A high-pass filter attenuates:
   a) High frequencies
   b) A band of frequencies
   c) Low frequencies
   d) Low and high frequencies
   e) None of the above

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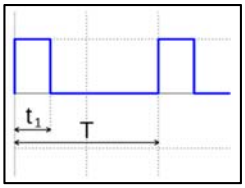
7. What is the period of a sine wave with a frequency f rad/sec?
   a) 2f sec
   b) $1/(2\pi f)$ sec
   c) $1/(2f^2)$ sec
   d) 1/f sec
   e) None of the above

8. The time constant of a first-order system tells when the output has gotten how far along the way to its steady-state value?
   a) 37%
   b) 60%
   c) $100*e^{-1}$ %
   d) $100*(1-e^{-1})$ %
   e) None of the above

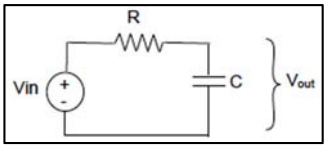
For questions 9 and 10 use the following figure of a PWM signal as reference:



9. What does T refer to?
   a) Pulse frequency
   b) Period duration
   c) Pulse duration
   d) Period frequency
   e) None of the above

10. Let t_1 = 0.2msec and T=1.0msec. What is the duty cycle of the PWM signal?
   a) 6msec
   b) 20%
   c) 16.7msec
   d) 16.7%
   e) None of the above

For questions 11 and 12 use the following figure as reference:

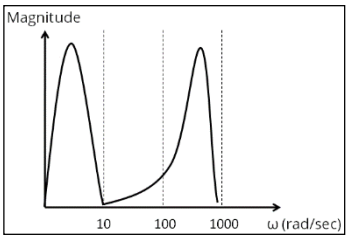


11. What is the equation that relates V_{out} to V_{in}?
   a) $V_{out} = V_{in}(1 - e^{-tRC})$
   b) $\boldsymbol{V_{out} = V_{in}(1 - e^{-t/RC})}$
   c) $V_{out} = V_{in}(1 - e^{-t})$
   d) None of the above

12. If you now change the circuit so that the resistor switches place with the capacitor, what type of filter would you have?
   a) Notch filter

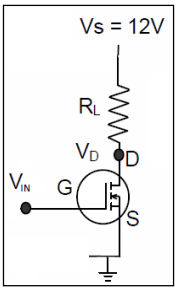
b) Band-pass filter
c) High pass filter
d) None of the above

You are using an accelerometer to measure the vertical motion of your car, with the intent of using an active suspension to cancel the low frequency motion of the car, but not the higher frequency vibrations. Below is your data. You need to design a RC filter that will pass only the low frequency motion. You set R = 100kΩ.
(hint: $\omega_{cutoff} = \frac{1}{\tau}$)



13. What should C be?
a) 1pF
b) 0.01μF
c) 1μF
d) 0.1μF
e) None of the above

For questions 14 and 15 assume that you create a circuit for controlling a light bulb with a MOSFET as shown below. You can model the light bulb as a resistor R_L. You can turn the light ON and OFF by controlling the input voltage to the MOSFET. You first decide to characterize the behavior of the MOSFET by measuring R_{DS} as a function of the input voltage and get the following values:



V_{IN}(volts)	R_{DS}(ohms)
0	100
2	90
3	80
3.9	4
5	0.01

14. Assume R_L = 3996 ohms. What is the value of V_D that corresponds to an input gate voltage of 3.9 volts?
a) 12V
b) 0.12V
c) 1.2V
d) 0.012V
e) None of the above

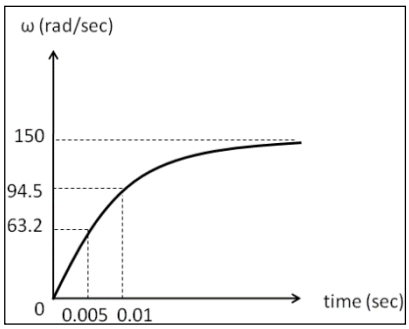
15. Which of the following is NOT true about the MOSFET?
a) The voltage at the source controls the current flow between the gate and drain.
b) The MOSFET is a type of transistor
c) The voltage at the gate controls the current flow between the drain and source
d) The MOSFET can be used in a circuit to control current flow to a DC motor.
e) none of the above

For questions 16-20 assume you are working with a DC brushed motor. Assume the motor's torque constant and back EMF constant is B, the internal resistance is R, and the inductance L.

16. You hold the shaft fixed and apply a voltage V. What is the steady-state torque you will feel?
a) BV/R
b) L/R
c) R/BV
d) V/B
e) VR/B

17. You now run the motor and measure its current to be 1.2Amps and torque to be 8N.m. What is the value of B?
a) 0.15 A/N.m
b) 6.67 N.m/A
c) 0.3 A/N.m
d) 3.33 N.m/A
e) None of the above

18. Assume that the time-response of the motor's no-load velocity is as shown below:



What is the time constant of the time-response?
a) 0.63sec
b) 0.0063sec
c) 10msec
d) 5msec

19. Using the plot above, what would be the value of the steady-state velocity if you found a way to double B?
a) 300 rad/sec
b) 150 rad/sec
c) 100 rad/sec
d) 75 rad/sec
e) None of the above

20. In lab 3, you controlled the DC motor using a PWM signal and the MOSFET. Which statement is true?
a) The motor acted as a low-pass filter, filtering the PWM pulses.
b) MOSFETs always work better with PWM signals.
c) A disturbance (like pressing the motor shaft with your finger) had no effect on the motor speed.
d) A disturbance (like pressing the motor shaft with your finger) made the control signal (PWM signal) change.
e) All of the above.

21. Assume that you power a motor with a 6V battery and that the motor draws 250mA. What is the power, in watts, dissipated by the motor?

a) 0.024W
b) 24W
c) 0.375W
d) 1.5W
e) None of the above

For questions 22 and 23 recall that the ODE for an RC low-pass circuit is given by:

$$RC\frac{dV_{out}}{dt} + V_{out} = V_{in}$$

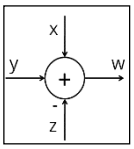
22. What is the transfer function of this system?

a) $G(s) = \frac{1}{s+\frac{1}{RC}}$
b) $G(s) = \frac{1}{s+RC}$
c) $\boldsymbol{G(s) = \frac{\frac{1}{RC}}{s+\frac{1}{RC}}}$
d) $G(s) = \frac{\frac{1}{RC}}{s+RC}$
e) None of the above

23. The response in the time-domain to a step change in voltage from 0 to 3V is given by:

a) $V_{out}(t) = (1 - e^{-t})$
b) $V_{out}(t) = \left(1 - e^{-\frac{t}{RC}}\right)$
c) $V_{out}(t) = 3(1 - e^{-t})$
d) $\boldsymbol{V_{out}(t) = 3\left(1 - e^{-\frac{t}{RC}}\right)}$
e) None of the above

24. Based on the summation block shown below. What is the value of w?

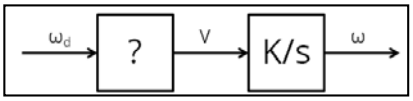


a) x + y – z
b) x * y * -z
c) w – z + x
d) w + z – x
e) None of the above

For questions 25 and 26 assume that you want to control the speed of a motor. You use a current amplifier with the motor and thus the speed of the motor is related to the input voltage to the current amplifier by the transfer function:

$$G(s) = \frac{K}{s}$$

You know very well the behavior of the motor and want to implement an open-loop controller for the motor.



25. What should be the numerator of the transfer function in the controller box (?) to make the output (ω) equal to the desired input (ω_d)?

a) ω
b) ω_d
c) V
d) s
e) K

26. What is a shortcoming of open loop control?

a) Need to have an accurate model of K
b) Can't handle unpredicted disturbances
c) An error has to develop before the controller acts
d) a) and c)
e) a) and b)

27. Which component is NOT necessary to implement a feedback-controlled system

a) An electronic control unit (micro-processor or computer)
b) A sensor
c) A power source
d) An actuator
e) none of the above

28. What function did you use in the Arduino IDE to create a PWM output signal?

a) createPWM()
b) digitalWrite()
c) analogWrite()
d) printPWM()
e) None of the above

29. When using the serial monitor, we must initialize communication through the COM port using a Serial.begin(baudRate); command in the Setup function. Which of the following statements is true?

a) The baud rate must be 9600
b) The baud rate must be 115200
c) The baud rate in the serial monitor must match that in the Serial.begin command.
d) The baud rate in the COM port must match that in the Serial.begin command.
e) none of the above

30. Which of the following is NOT a common additive manufacturing technique?

a) 3D printing
b) Stereolithography (SLA)
c) Computer Numerical Control (CNC Router)
d) Fused Deposition Modeling (FDM)
e) none of the above