EECS 145L Final Examination Solutions (Fall 1999)

UNIVERSITY OF CALIFORNIA, BERKELEY
College of Engineering, Electrical Engineering and Computer Sciences Department

1a The **ideal op-amp** has infinite differential gain while the **ideal instrumentation amplifier** has a fixed gain (set by external resistors) over a range of frequencies.

[1 point off for ideal op amp gain falling as 1/f, which is a property of the realistic op-amp]

[2 points off for ideal instrumentation amplifer having infinite differential gain]

1b The **incandescent lamp** has thermally agitated electrons in a hot filament that emit black body radiation. (The lamp is hot and the color spectrum is broad.) The **fluorescent lamp** emits light when electrons excited to a higher energy level drop to a lower energy level. (The lamp is cool and the spectrum has emission lines.)

[3 points off if incandescent has no hot filament or thermally agitated eleectrons or black body radiation]

[2 points off if incandescent has a broad wavelength spectrum but no hot filament]

[3 points off if fluorescent excitation or energy levels not mentioned]

[2 points off if fluorescent emission is in discrete wavelenthgs but energy levels not mentioned]

1c The **platinum resistance thermometer** is a metal whose resistance increases approximately linearly with increasing temperature and the **thermistor** is a semiconductor whose resistance decreases exponentially with increasing temperature.

[2 points off for not mentioning increase vs. decreasing resistance with increasing temperature]

[2 points off for not mentioning metal vs. semivconductor difference]

2a In the **Peltier Thermoelectric Heat Pump** electrons pass through a series of n-type and p-type semiconductive elements. The "electron gas" is heated by compression when it is forced by an external power supply to enter the p-type material and cools by expansion when it enters the n-type material.

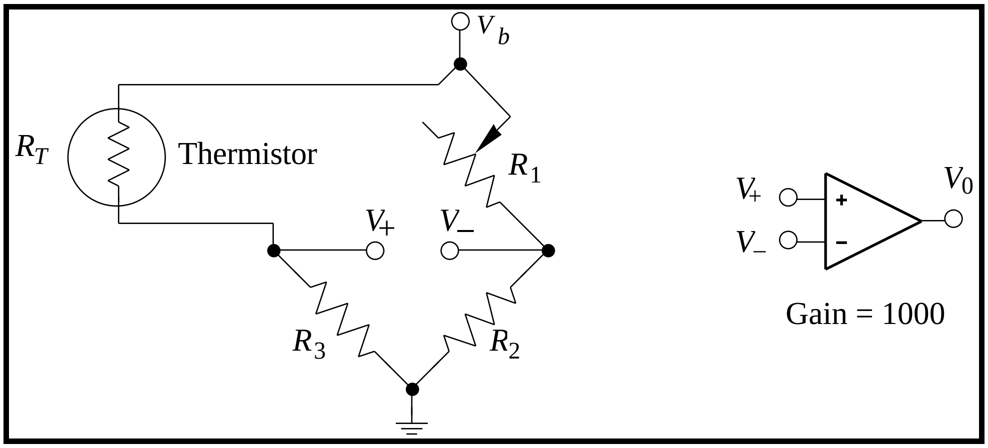
2b The **Stepping Motor** consists of a magnetic element surrounded by a series of coils. Current passing through the coils makes a series of magnetic wells. As current is switched among the coils, the position of the magnetic wells changesa and the magnetic element rotates

2c In the **light emitting diode** an electric potential drives electrons into the conduction band and the electrons produce light when they return to the ground state.

3a For maximum sensitivity at 30°C, $R_3 = R_4 = 10\ k\Omega$.

For $V_0 = 0$ at 30°C, $R_1 = 10\ k\Omega$. $V_b = 0.1$ V

At 31 °C, $V_+ = (0.1\ V)\ (10{,}000\ \Omega)/(9{,}608 + 10{,}000\ \Omega) = 0.051000$ V $V_- = 0.050000$



3b Gain = V_0 / ($V_+ - V_-$) = (1 V)/(0.00100 V) = 1000, Bandwidth = 10^6 Hz/1000 = 1000 Hz.

3c $V_{rms} = \sqrt{\Delta f (D_1 G)^2}$ from the equation sheet.

V_{rms} = (31.4 $Hz^{1/2}$) (1 μV $Hz^{-1/2}$) (1000) = 31.4 mV

[2 points off for not mutiplying by the gain]

3d $T_{rms} = V_{rms}/(dV_0/dT)$ = (31.4 mV)/(1 V/°C) = 0.0314 °C rms

[2 points off for 30.0314 °C]

3e A low-pass filter with f_c slighlty above 1 Hz will reduce the noise from 31.4 mV to 1 mV without reducing the signal

[3 points off if low-pass filter not used] [3 points off if f_c not given]

[6 points off for using a notch filter]

[4 points off for increasing the amplifier gain to reduce the bamdwidth- a gain of 10^6 would be needed and this would cause saturation]

4a Green is reflected, so all other wavelgths are absorbed.

4b Fluorescent

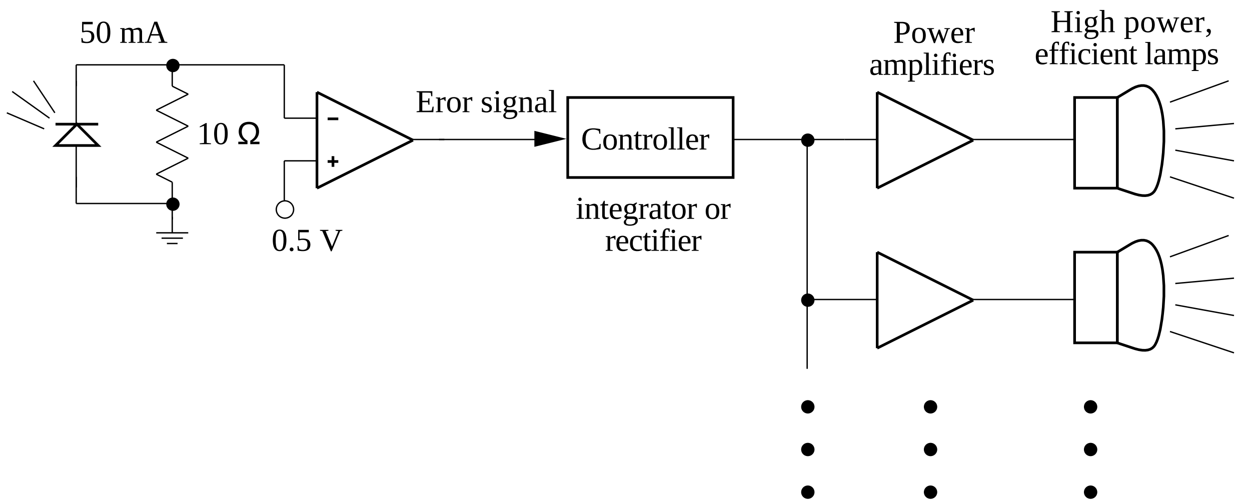
4c Assuming 100% quantum efficiency, the power received by a 1 cm^2 photodetector under full sunlight is (10^{-4} m^2) (1000 W m^{-2}) = 0.1 W.

0.1 W of 2 eV photons produces 50 mA of closed-loop photovoltaic current.

Open-circuit conditions produces 0 mA and ≈0.6 V max (voltage saturation).

Load resistor must be < 0.6 V/0.05 A = 12 Ω or photodiode will saturate.

A 10 Ω load resistor will produce 0.5 V when the photodiode receives full sunlight. This determines the set point voltage.

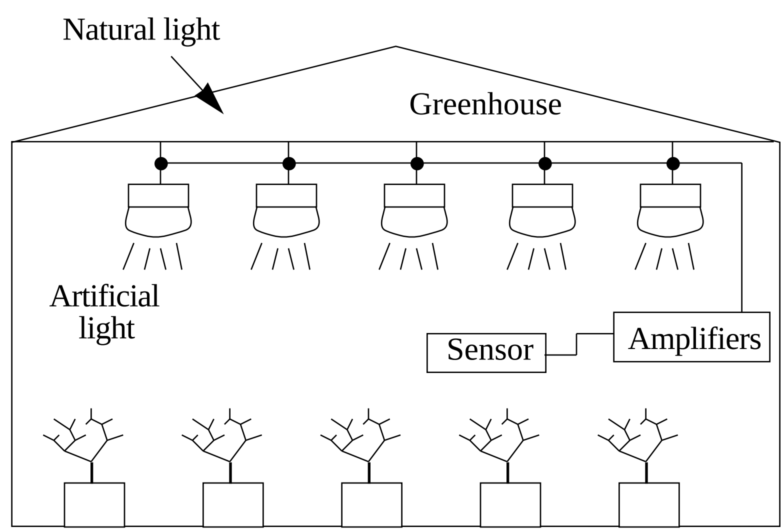


[2 points off if load resistor is > 12 Ω]

[2 points off for omitting the factor of 2 eV in converting from watts to amps]

[3 for omitting a controller- without rectification both positive and negative error signals will generate more artificial light. An integrator is even better- a positive error signal will increase the lamp drive and a negative error signal will reduce the lamp drive.]

4d



5a Sensor: thermistor Actuator: thermoelectric heat pump

5b Sensor: thermocouple of platinum resistance thermometer Actuator: resistive heater

Another correct answer is a bimetallic switch, which acts both as a sensor and an actuator

[3 points off for using a thermoelectric heat pump as an actuator- it is a semiconductor that would be destroyed at 500 °C]

5c Sensor: piezoelectric crystal or embedded piezoresistors in a silicon disk

Actuator: motor plus compresssor pump or solinoid plus piston

5d Sensor: Circular resistor or digital encoder Actuator: stepping motor

145LFinal Examination score distribution:

101-110		111-120		121-130	
131-140	1	141-150		151-160	
161-170	2	171-180	3	181-190	7
191-200	4				

undergraduate average = 179.6
graduate average = 188.0

145L Course Grade Distribution

Grade	Undergraduate Scores	Graduate Scores
A+	959	
A	929, 934, 949, 957	929, 950
A–		
B+	901, 901, 904, 906	
B	872, 889, 890	
B–	823, 845	
C+		
C		
C–	716	
Maximum	1000	1000
Average	891.7	939.5