EE 4770 — Homework 2 — Due: 2 March 1998

Problem 1: Design a system, called the *Portable Optical Orientation Helper*, *POOH*, to determine the angle with respect to a beacon. POOH should determine the angle, in degrees, formed by north, the beacon, and the device, in a clockwise direction. For example, if POOH indicates 90° then the user is east of the beacon.[1] The beacon consists of a light surrounded by a *non-dispersing gradient filter,* which works as follows: The filter is transparent to light at a wavelength of 500 nm. The filter is positioned around the light so that for light at a wavelength of 700 nm the filter varies linearly from completely transparent, at an angle of 0° to completely opaque just before angle 360°. (As with the POOH output, the angles are formed by the north, beacon, and the viewer.) The filter's properties vary with angle, but not with height. Two monochromatic filters can be used to construct POOH, one is transparent to light at 500 nm but is opaque to other wavelengths, the other is transparent to light at 700 nm but is opaque to other wavelengths. The beacon light source emits one light watt at a wavelength of 500 nm and three light watts at a wavelength of 700 nm. Assume that there are no reflections and no ambient light at the wavelengths of interest, so the only light reaching the detector comes directly from the beacon. Also assume that the filter is ideal in the sense that there is no dispersion: only rays on a straight line from the light to the system need be considered. POOH can be used from a distance of one meter to 10 meters from the light source.

Design the system using photodiodes with response $H_{t1}(E) = E\frac{50\,\mu\mathrm{A}}{\mathrm{mW}/\mathrm{cm}^2}$. The photodiodes are fully sensitive to light at wavelengths of 500 nm and 700 nm. Provide a schematic showing all voltage and current sources. The angle should be written to variable `alpha`. Indicate the minimum precision of the angle. (Note that no particular precision is required.) *Hint: The solution is fairly simple.*

Problem 2: Design a circuit to convert the difference in temperature between two points, $x = T_1 - T_2$, to a voltage, $H(x) = x\frac{\mathrm{V}}{\mathrm{K}}$. The circuit should have a low output impedance. The temperature at both points varies from 250 K to 350 K, but the temperature difference will be in the range $[-5^\circ\,\mathrm{K}, 5^\circ\,\mathrm{K}]$. The temperature at point 1, T_1, is to be measured by a voltage-type integrated temperature sensor with response $H_t(T) = T\frac{10\,\mathrm{mV}}{\mathrm{K}}$ and the temperature at point 2, T_2, is to be measured with a current-type integrated temperature sensor with response $H_t(T) = T\frac{\mu\mathrm{A}}{\mathrm{K}}$. Use as few components as possible.

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[1] Certain aircraft navigation beacons which are similar in function—but not implementation—indicate the opposite direction, for example, 270° when east of the beacon, which would be the direction of travel if heading towards the beacon.