



North Carolina
School of Science
and Mathematics

Demonstration of Light Emitting Diodes and Alternating Current

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**Joint Chesapeake and North Carolina
Section AAPT Meeting**

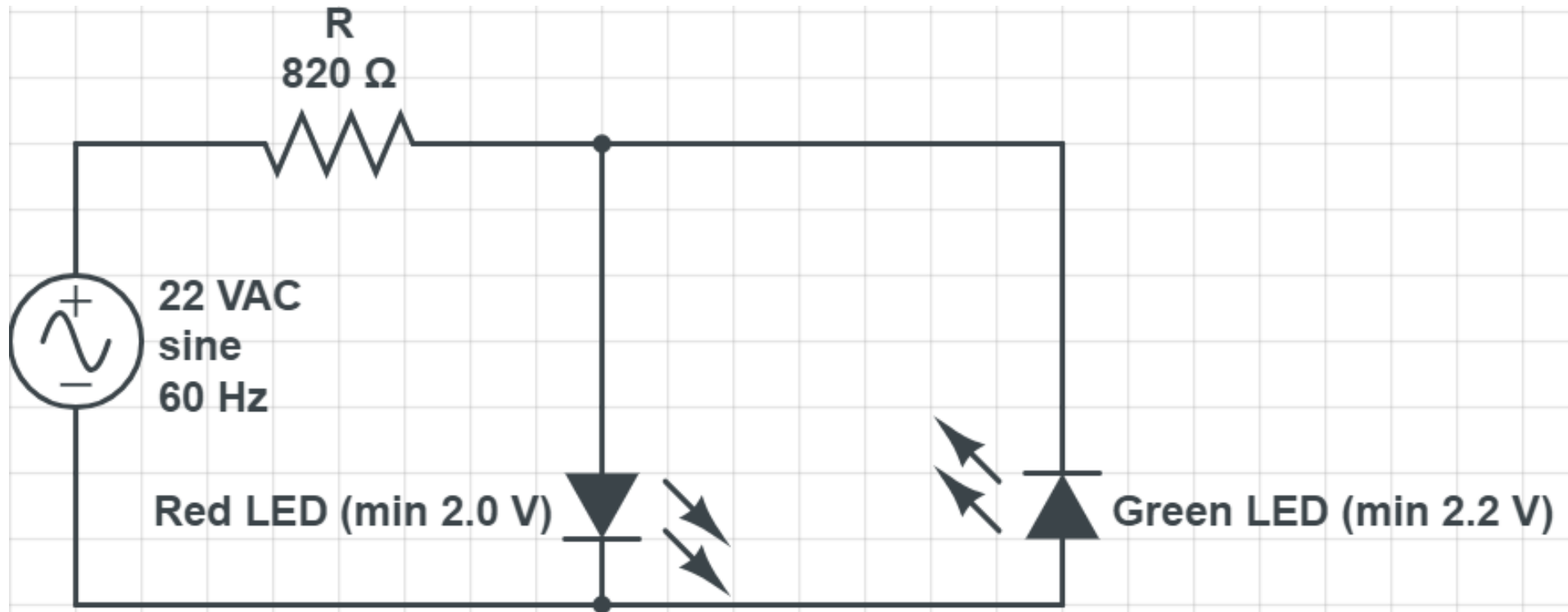
10/19/24



Circuit Diagram

Red and Green LEDs are wired in parallel but with opposite polarities. At any instant, only one of the LEDs is forward biased by the AC voltage source.

Reference: Harrich, L. "AC Made Visible," The Physics Teacher 22, 48 (1984)

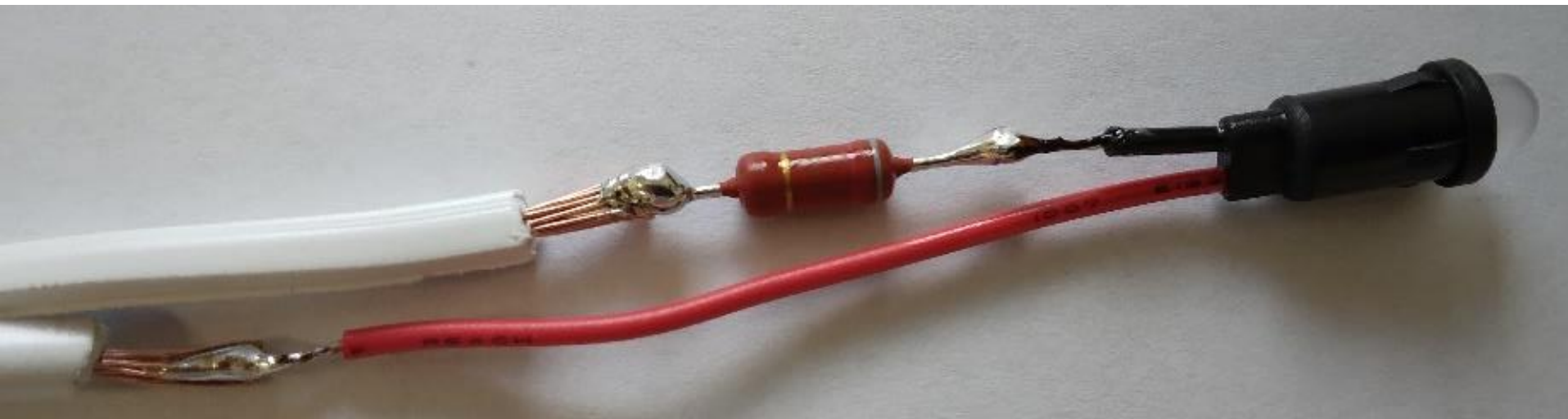




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Demo Construction from Kit

Off-the-shelf bicolor LED contains the red and green LEDs. Three solder joints are needed to make the connections to a lamp cord. Other ends of the lamp cord connect via wire nuts to a 22 VAC “wall wart” transformer box.





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Making AC Visible

Wave the end of the lamp cord back and forth in a darkened room.

Which color makes longer streaks ? Why ?

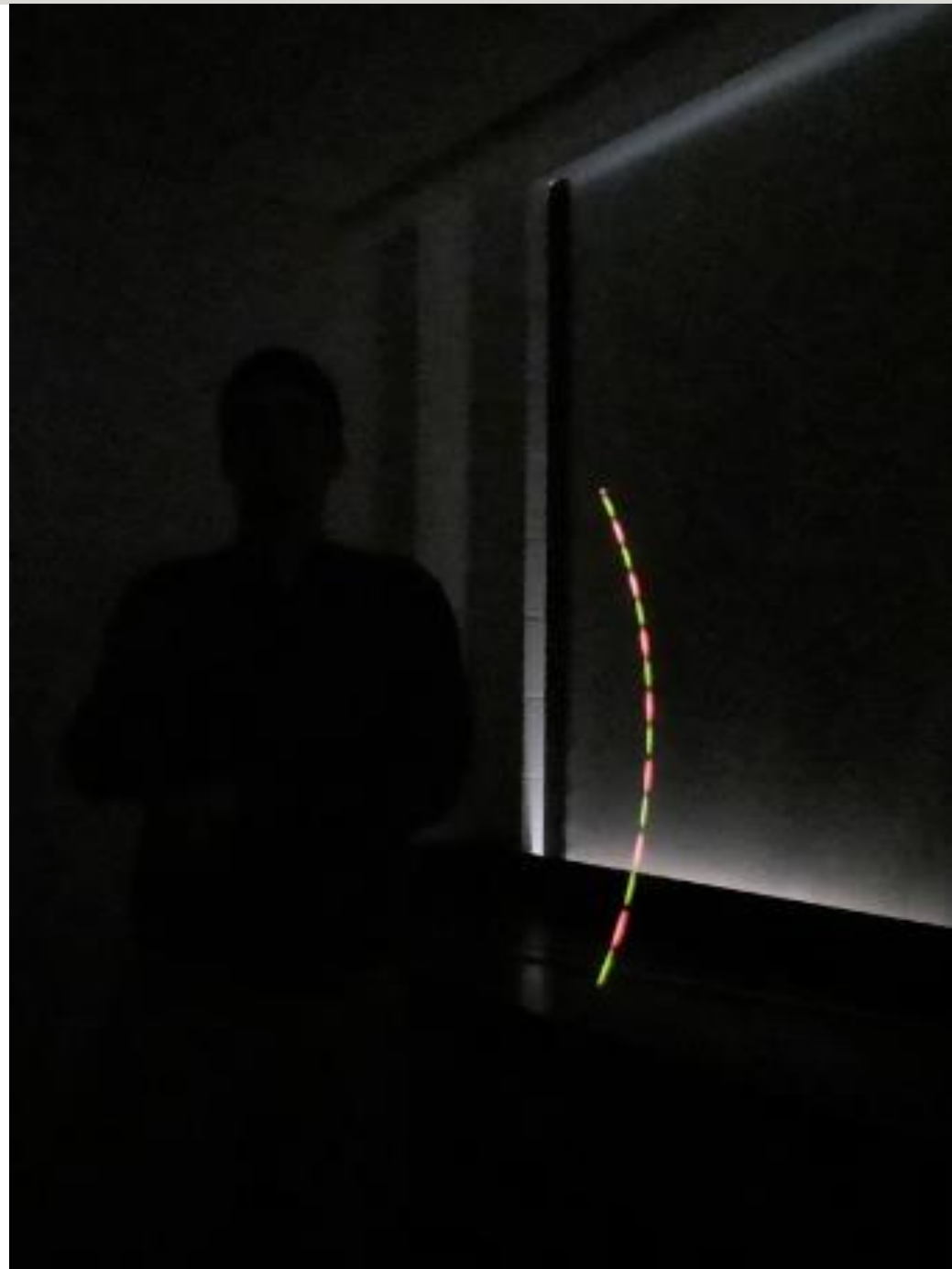


Photo by Megan Alvord



IUPAC Periodic Table of the Elements

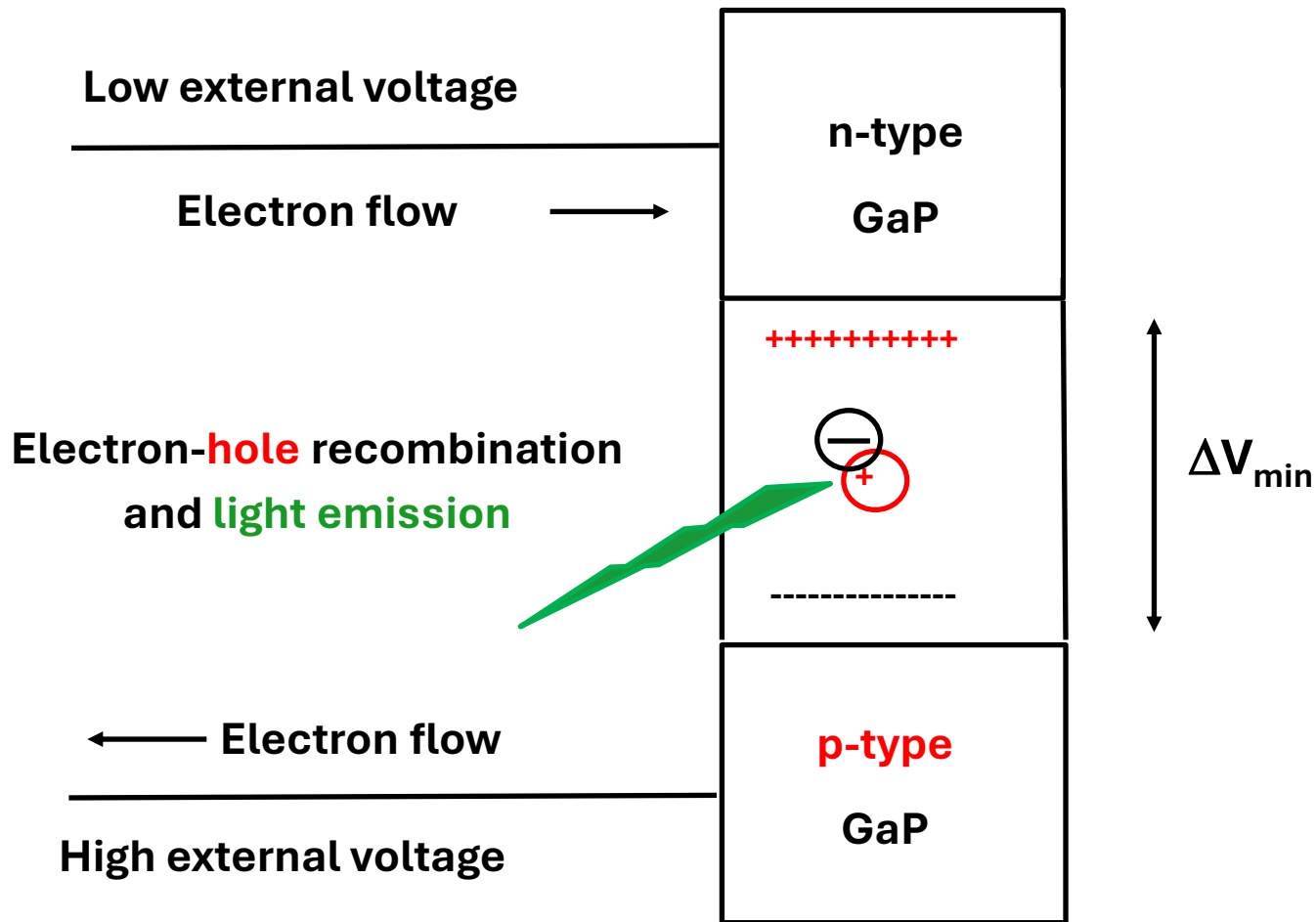
1 H hydrogen 1.008 + 0.002																	18 He helium 4.0026 + 0.0001						
3 Li lithium 6.94 + 0.01	4 Be beryllium 9.0122 + 0.0001																	5 B boron 10.81 + 0.02	6 C carbon 12.011 + 0.002	7 N nitrogen 14.007 + 0.001	8 O oxygen 15.999 + 0.001	9 F fluorine 18.998 + 0.001	10 Ne neon 20.180 + 0.001
11 Na sodium 22.990 + 0.001	12 Mg magnesium 24.305 + 0.001																	13 Al aluminum 26.982 + 0.001	14 Si silicon 28.086 + 0.001	15 P phosphorus 30.974 + 0.002	16 S sulfur 32.06 + 0.02	17 Cl chlorine 35.45 + 0.01	18 Ar argon 39.948 + 0.001
19 K potassium 39.098 + 0.001	20 Ca calcium 40.078 + 0.008	21 Sc scandium 44.956 + 0.001	22 Ti titanium 47.88 + 0.001	23 V vanadium 50.942 + 0.001	24 Cr chromium 51.996 + 0.001	25 Mn manganese 54.938 + 0.001	26 Fe iron 55.845 + 0.002	27 Co cobalt 58.933 + 0.001	28 Ni nickel 58.69 + 0.001	29 Cu copper 63.546 + 0.002	30 Zn zinc 65.38 + 0.02	31 Ga gallium 69.723 + 0.001	32 Ge germanium 72.630 + 0.001	33 As arsenic 74.922 + 0.001	34 Se selenium 78.96 + 0.001	35 Br bromine 79.904 + 0.001	36 Kr krypton 83.80 + 0.002						
37 Rb rubidium 85.468 + 0.001	38 Sr strontium 87.62 + 0.01	39 Y yttrium 88.906 + 0.001	40 Zr zirconium 91.224 + 0.002	41 Nb niobium 92.906 + 0.001	42 Mo molybdenum 95.94 + 0.01	43 Tc technetium [98]	44 Ru ruthenium 101.07 + 0.002	45 Rh rhodium 101.07 + 0.01	46 Pd palladium 106.42 + 0.01	47 Ag silver 107.87 + 0.01	48 Cd cadmium 112.41 + 0.01	49 In indium 114.82 + 0.01	50 Sn tin 118.71 + 0.01	51 Sb antimony 121.76 + 0.01	52 Te tellurium 127.60 + 0.01	53 I iodine 126.905 + 0.001	54 Xe xenon 131.29 + 0.01						
55 Cs cesium 132.91 + 0.01	56 Ba barium 137.33 + 0.01	57-71 lanthanoids	72 Hf hafnium 178.49 + 0.01	73 Ta tantalum 180.95 + 0.01	74 W tungsten 183.84 + 0.01	75 Re rhenium 186.21 + 0.01	76 Os osmium 190.23 + 0.01	77 Ir iridium 192.22 + 0.01	78 Pt platinum 195.08 + 0.01	79 Au gold 196.97 + 0.01	80 Hg mercury 200.59 + 0.01	81 Tl thallium 204.38 + 0.01	82 Pb lead 207.2 + 0.1	83 Bi bismuth 208.98 + 0.01	84 Po polonium [209]	85 At astatine [210]	86 Rn radon [222]						
87 Fr francium [223]	88 Ra radium [226]	89-103 actinoids	104 Rf rutherfordium [261]	105 Db dubnium [262]	106 Sg seaborgium [266]	107 Bh bohrium [264]	108 Hs hassium [277]	109 Mt meitnerium [268]	110 Ds darmstadtium [285]	111 Rg roentgenium [286]	112 Cn copernicium [284]	113 Nh nihonium [284]	114 Fl flerovium [289]	115 Mc moscovium [288]	116 Lv livermorium [293]	117 Ts tennessine [294]	118 Og oganeson [294]						

57 La lanthanum 138.91 + 0.01	58 Ce cerium 140.12 + 0.01	59 Pr praseodymium 140.91 + 0.01	60 Nd neodymium 144.24 + 0.01	61 Pm promethium [145]	62 Sm samarium 150.36 + 0.02	63 Eu europium 151.96 + 0.01	64 Gd gadolinium 157.25 + 0.01	65 Tb terbium 158.93 + 0.01	66 Dy dysprosium 162.50 + 0.01	67 Ho holmium 164.93 + 0.01	68 Er erbium 167.26 + 0.01	69 Tm thulium 168.93 + 0.01	70 Yb ytterbium 173.05 + 0.01	71 Lu lutetium 174.967 + 0.01
89 Ac actinium [227]	90 Th thorium 232.04 + 0.01	91 Pa protactinium 231.04 + 0.01	92 U uranium 238.03 + 0.01	93 Np neptunium [237]	94 Pu plutonium [244]	95 Am americium [243]	96 Cm curium [247]	97 Bk berkelium [247]	98 Cf californium [251]	99 Es einsteinium [252]	100 Fm fermium [257]	101 Md mendelevium [258]	102 No nobelium [259]	103 Lr lawrencium [260]



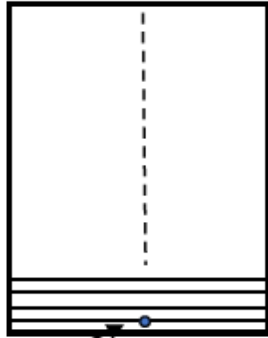


P-N Junction in Forward Bias





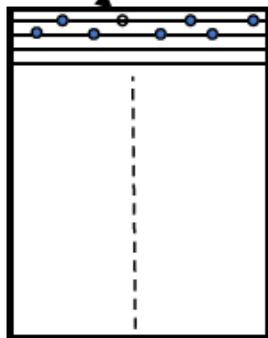
Band Gap



Conduction band (only lowest few unoccupied energy levels are shown)

Electron in conduction band

$$\Delta E_{\text{gap}} \approx e * \Delta V_{\text{min}}$$



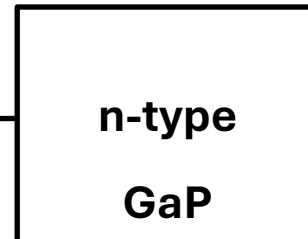
Hole" in valence band

Valence band (only highest few occupied energy levels are shown)

P-N Junction

Low external voltage

Electron flow →



n-type
GaP

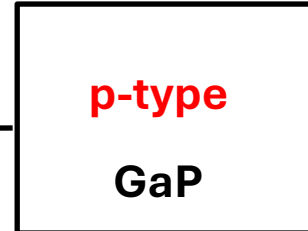
+++++



Electron-hole recombination
and light emission

← Electron flow

High external voltage



p-type
GaP

ΔV_{min}



Estimating Planck's Constant

Energy of photon = $h \cdot f \approx$ band gap of the LED $\approx e \cdot \Delta V_{\min}$

Color	Wavelength λ	Minimum Forward Voltage ΔV_{\min}	$h = E_{\text{photon}} / f$ $= (e \cdot \Delta V_{\min} \cdot \lambda) / c$
Green	565 nm	2.2 Volts	$7.4 \cdot 10^{-34} \text{ J} \cdot \text{s}$
Red	700 nm	2.0 Volts	$4.1 \cdot 10^{-34} \text{ J} \cdot \text{s}$

Average value of h from LED data = $5.7 \cdot 10^{-34} \text{ J} \cdot \text{s}$

Known value of Planck's constant = $6.6 \cdot 10^{-34} \text{ J} \cdot \text{s}$

Reference: O'Connor, P.J. and O'Connor, L.R.

“Measuring Planck's Constant Using a Light Emitting Diode,” The Physics Teacher 12, 423 (1974)



Acknowledgment

**Chuck Britton, retired NCSSM physics
instructor**

References

Harrich, L. “AC Made Visible,” The Physics Teacher 22, 48 (1984)

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THANK YOU !!