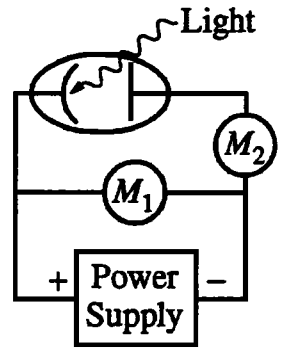
AP® Physics B (Operational)
2004 Sample Student Responses



6. (10 points)

A student performs a photoelectric effect experiment in which light of various frequencies is incident on a photosensitive metal plate. This plate, a second metal plate, and a power supply are connected in a circuit, which also contains two meters, M_1 and M_2, as shown above.

The student shines light of a specific wavelength λ onto the plate. The voltage on the power supply is then adjusted until there is no more current in the circuit, and this voltage is recorded as the stopping potential V_S.

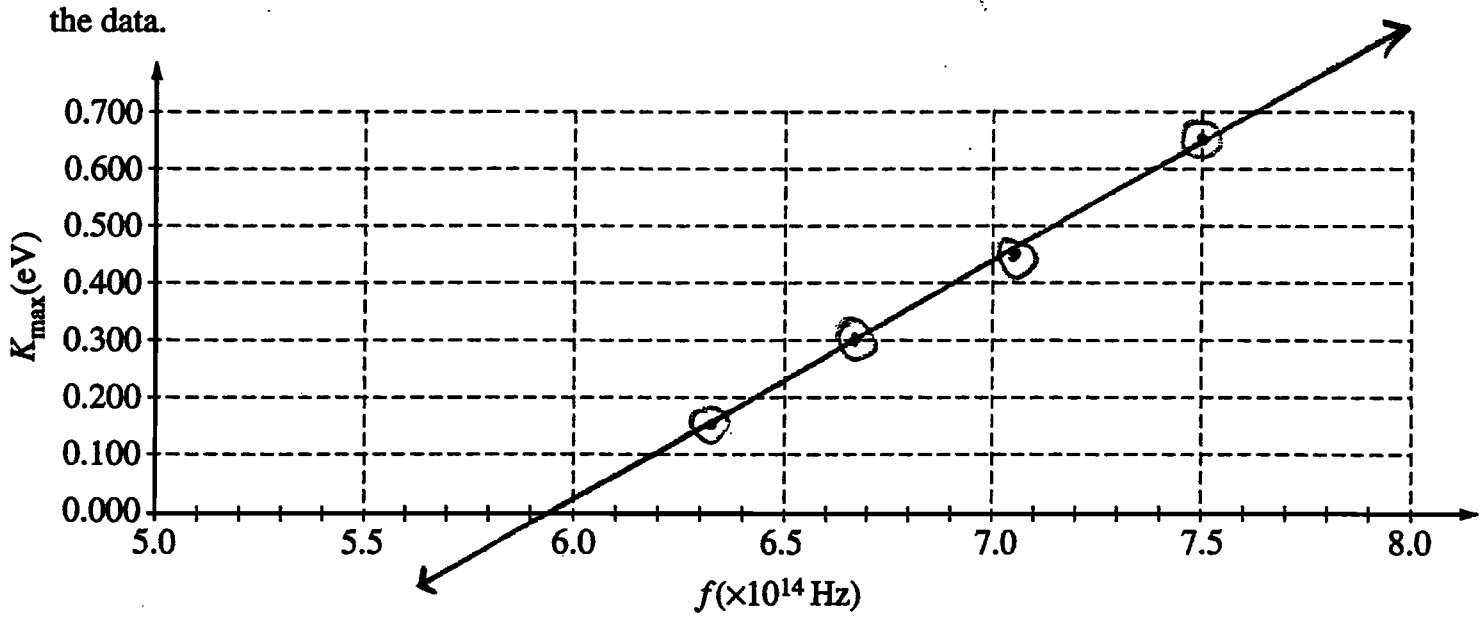
The student then repeats the experiment several more times with different wavelengths of light. The data, along with other values calculated from it, are recorded in the table below.

λ (m)	4.00×10^{-7}	4.25×10^{-7}	4.50×10^{-7}	4.75×10^{-7}
V_S (volts)	0.65	0.45	0.30	0.15
f (Hz)	7.50×10^{14}	7.06×10^{14}	6.67×10^{14}	6.32×10^{14}
K_{max} (eV)	0.65	0.45	0.30	0.15

(a) Indicate which meter is used as an ammeter and which meter is used as a voltmeter by checking the appropriate spaces below.

	M_1	M_2
Ammeter		✓
Voltmeter	✓	

(b) Use the data above to plot a graph of K_{max} versus f on the axes below, and sketch a best-fit line through the data.



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(c) Use the best-fit line you sketched in part (b) to calculate an experimental value for Planck's constant.

$$h = \frac{\Delta K_{max}}{\Delta f} = \frac{(0.30\,eV - 0.15\,eV)}{(6.67\times10^{14}\,Hz - 6.32\times10^{14}\,Hz)}$$

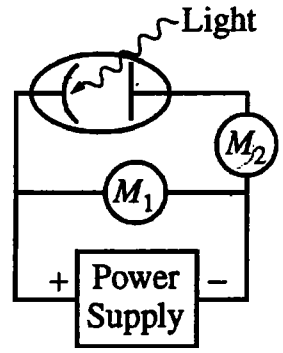
$$h = 4.29\times10^{-15}\ eV\cdot s$$

(d) If the student had used a different metal with a larger work function, how would the graph you sketched in part (b) be different? Explain your reasoning.

$K_{max} = hf - \phi$

If a metal was used with a larger work function, meaning ϕ was greater, then Kmax would have been less for each data point, thus shifting the entire graph down a certain number of units. However, a larger work function does not affect the relationship between Kmax and f meaning that the slope of the graph Kmax vs f would be the same. The kmax of all the points would be reduced equally (by some $\phi_{new} - \phi_{old}$) and therefore the change in Kmax would not be affected (the change in ϕ would cancel each other out.) Therefore the experimental value for Planck's constant, $\Delta K_{max}/\Delta f$, would not be affected.

B1



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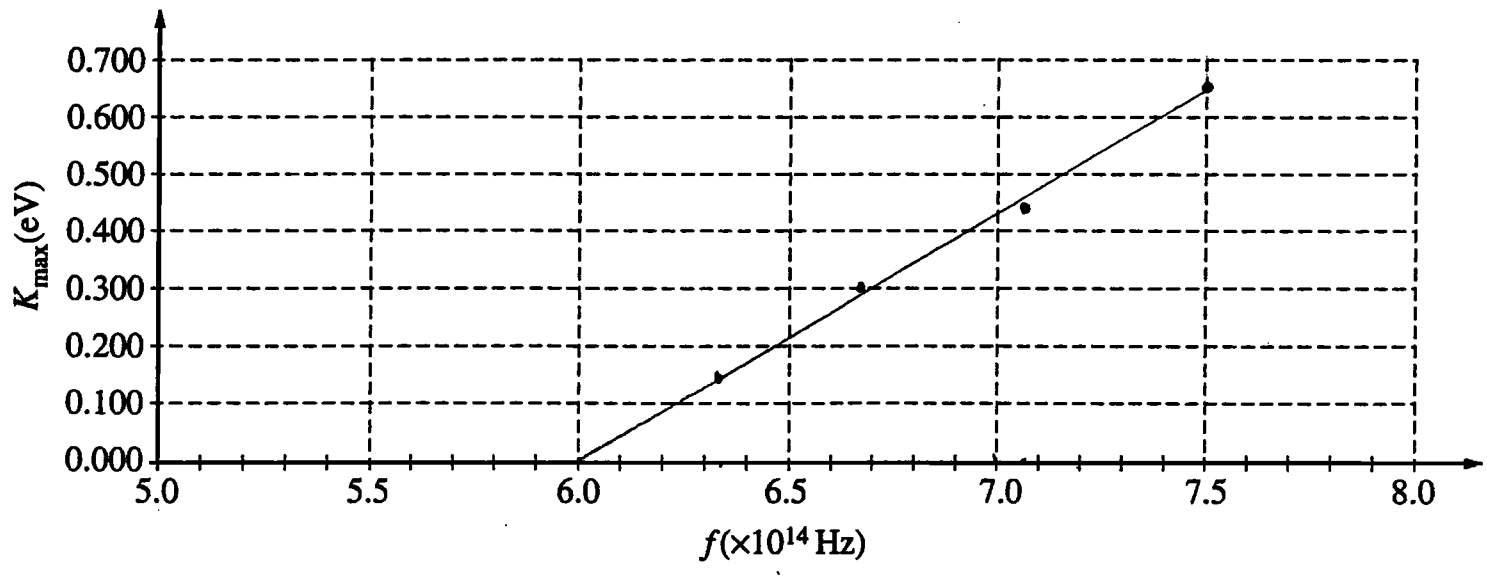

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(c) Use the best-fit line you sketched in part (b) to calculate an experimental value for Planck's constant.

$h_{experimental} = slope = \frac{\Delta y}{\Delta x}$

$h = \frac{(.65 - .15)}{(7.5E14 - 6E14)} = \frac{.5}{1.5E14}$

$h_{exp.} = 3.33 \times 10^{-15}\ eV \cdot s$

(d) If the student had used a different metal with a larger work function, how would the graph you sketched in part (b) be different? Explain your reasoning.

The graph would have been moved to the right in regard to the x-axis, but with the same slope. For a plate with a larger work function, the frequency of light needed for the photoelectric effect would increase, thus moving the graph to the right (see picture).