Assignment 3
Jane Doe

1 Numerical Integration and Differentiation

1.1 Numerical Integration

Problem 1. *Haberman 5.4.2a (5pts)*

Davisson and Germer obtained a (first order, $n = 1$) peak of diffracted electrons at (approximately) $50°$(measured from the surface normal) for an acceleration potential of 54 V.

Solution.

From the Bragg formulas $n\lambda = 2d\sin\theta = D\sin\phi$, with $n = 1$, the fact that $2\theta = 180° - \phi$, and equation (1.2) we have

$$\begin{aligned} d &= \frac{D\sin\phi}{2\sin\theta} \quad \Bigg| \quad \phi = 50°, \quad \theta = 65°, \quad D = 0.215 \text{ nm} \\ &= \frac{0.76604}{2(0.906308)}(0.215 \text{ nm}) \\ &= (0.4226)(0.215 \text{ nm}) \\ &= \boxed{0.091 \text{ nm.}} \end{aligned}$$

Note that Figure 2.1 is rather dull, but at least this hyperlink is a subtle shade of blue. Alternatively, making use of the acceleration potential, the de Broglie relation $\lambda = {}^{h}/_{p}$, and the fact that momentum $p = \sqrt{2m_e eV}$, we have

$$\begin{aligned} \lambda &= \frac{h}{\sqrt{2m_e eV}} && (1.1) \\ &= \frac{6.626068 \times 10^{-34} \text{ m}^2\text{kg/s}}{\sqrt{2(9.109 \times 10^{-31} \text{ kg})(1.602 \times 10^{-19} \text{ C})(54 \text{ V})}} && (1.2) \\ &= \frac{6.626068 \times 10^{-34} \text{ m}^2\text{kg/s}}{\sqrt{1.576002744 \times 10^{-47} \text{ m}^2\text{kg}^2/\text{s}^2}} && (1.3) \\ &= 1.668954 \times 10^{-10} \text{ m} && (1.4) \end{aligned}$$

α	β	γ
δ	ϵ	τ

Table 1.1. A table.

We also note that verbatim code must be inserted via the `\input` command:

```
\begin{figure}[ht!]
\vspace{0pt}
\centering
\includegraphics[width=1in]{figure.jpg}
\caption{A figure.}
\label{figure2}
\end{figure}
```

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1.3 Numerical Differentiation

Problem 2. *The Helmholtz Equation (5pts)*

Use the concepts of wave number and angular frequency in the expression of a one-dimensional classical wave that is traveling to the right and show that this wave function obeys the classical wave equation.

Solution.

To show that the functional expression $y(x,t)$ of a one-dimensional, rightward-traveling classical wave obeys the classical wave equation

$$\frac{\partial^2 y}{\partial x^2} = \frac{1}{v_p^2}\frac{\partial^2 y}{\partial t^2},$$

Helmholtz Equation

it suffices to show that $y(x,t)$ is a solution to the one-dimensional Helmholtz equation.

Expressed in trigonometric form, the wave function is $y = A\cos(\omega t - kx)$, with angular frequency $\omega = 2\pi f$ and wave number $k = {}^{2\pi}/_{\lambda}$.

Since the wavelength

$$\delta\lambda = \frac{v_p}{f}, \tag{2.1}$$

$\delta k = \frac{2\pi f}{v_p} = \frac{\omega}{v_p}$. The wave function is then $\delta y = A\cos\left(\omega t - \frac{\omega}{v_p}x\right)$.

α	β	γ
δ	ϵ	τ

Table 2.1. Table One

Substituting into the Helmholtz equation, we have Figure 2.1.

Figure 2.1. A rather boring figure.

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