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HW #2

EECU 101

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1)

$C = (S + N_D + N_P)A$

(a)

$VAR(C) = VAR(AS + AN_D + AN_P)$

$= A^2 VAR(S) + A^2 VAR(N_D) + A^2 VAR(N_P)$ (S is constant, so $VAR(S) = 0$)

$= A^2 + A^2 mean(S) + A^2 mean(N_D)$ (N_D is constant, so $mean(N_D) = 0$)

$= A^2 + A^2 S = \boxed{A^2(1+S)}$

(b)

$\text{signal-to-noise} = \frac{E(C)}{\sigma(C)}$

$= \frac{E(C)}{\sqrt{VAR(C)}}$

$= \frac{E(S) + E(N_D) + E(N_P)}{A\sqrt{1+S}}$

$= \frac{E(S) + 0 + E(N_P)}{\sqrt{1+S}}$ ← poisson

$= \frac{S + VAR(N_P)}{\sqrt{1+S}}$

$= \frac{S + E(S) + 0}{\sqrt{1+S}}$ (N_P is constant, so $E(N_P) = 0$)

$= \boxed{\frac{2S}{\sqrt{1+S}}}$

(c)

$\frac{2S}{\sqrt{1+S}} > 100$

$\Rightarrow \frac{4S^2}{1+S} > 100 \Rightarrow \frac{4S_{min}^2}{1+S_{min}} = 10000$

$\Rightarrow S_{min}^2 - 25 S_{min} - 25 = 0$

$\Rightarrow \boxed{S_{min} = 251}$

2)

$\frac{1}{z'} + \frac{1}{-z} = \frac{1}{f}$ $\quad f = 0.04\,m$, $d = 0.02\,m$

$z' = 0.06\,m$

$\frac{b}{d} = \frac{|z - z'|}{z'}$

(a)

$\frac{1}{z'} + \frac{1}{z} = \frac{1}{f} \Rightarrow \frac{1}{0.06} + \frac{1}{z} = \frac{1}{0.04}$

$\Rightarrow z = \frac{1}{\frac{1}{0.04} - \frac{1}{0.06}} = \boxed{0.12\,m}$

(b)

size of one potential well = $\frac{0.02}{\sqrt{N}} = 0.004\,cm$

$\frac{b}{d} = \frac{0.004}{d} \Rightarrow b = 0.004\,cm$

$\frac{b}{d} = \frac{|z - z'|}{z'} \Rightarrow z'\frac{b}{d} - z' = -z'$

$\Rightarrow z = \frac{-z'}{\frac{b}{d} - 1} = \frac{-6.0}{\frac{0.004}{4} - 1}$

$= 6.006\,cm$

$$\frac{1}{z'} + \frac{1}{z} = \frac{1}{f}$$

$$\Rightarrow \frac{1}{6.006} + \frac{1}{z} = \frac{1}{4}$$

$$\Rightarrow z = \frac{1}{\frac{1}{6.006} - \frac{1}{4}} = -11.976\text{cm}$$

$$|z - \bar{z}| = |-12 + 11.976| = \boxed{0.024\text{cm}}$$

3)

$$D = (S + N_A + N_B)A + N_C$$

$$\text{VAR}(N_A) = \sigma_A^2$$

$$\text{VAR}(N_B) = S$$

$$\text{VAR}(N_C) = \sigma_C^2$$

(a)

$$E(D) = AE(S) + \cancel{AE(N_A)}^{0} + \cancel{AE(N_B)}^{0} + \cancel{A(\text{what})}^{0}$$

$$= \boxed{AS}$$

$$\text{VAR}(D) = A^2\cancel{\text{VAR}(S)}^{0} + A^2\text{VAR}(N_A) + A^2\text{VAR}(N_B) + \text{VAR}(N_C)$$

$$= A^2\sigma_A^2 + A^2 S + \sigma_C^2$$

$$= \boxed{AE(D) + \underbrace{A^2\sigma_A^2 + \sigma_C^2}_{\sigma_\varepsilon^2}}$$

(b) Separate paper.

(c) Separate paper.

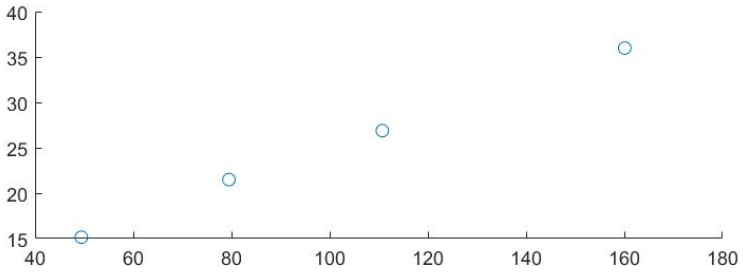
3.

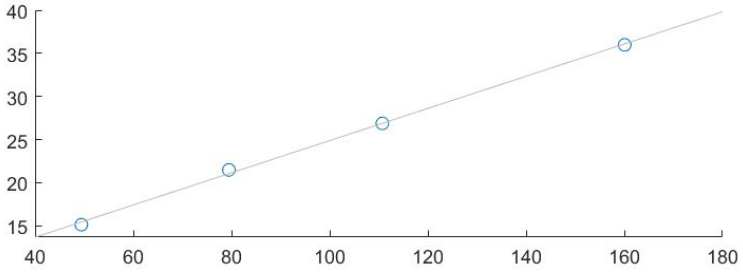
Part b:

```
Select C:\Users\jcylim\Documents\Visual Studio 2017\EECS 101\HW2\Debug\HW2.exe
image1.raw: 49.422600 15.144367
image2.raw: 79.478500 21.492956
image3.raw: 110.721100 26.886707
image4.raw: 160.079193 35.986778
Press any key to exit:
```

Part c:

This part was done on MATLAB, and the estimated *A* is .1866 and σ_C^2 is 6.2344.






```
>> hw2

A =

    0.1866


variance_of_C =

    6.2344
```