$\boxed{14.1}$ $E(V) = 2E_F - 2E_c\, e^{-2/N_F V}$

$$f(a) \approx \sum_{n=0}^{\infty} \frac{f^{(n)}(a)}{n!}(x-a)^n$$

$$f(0) \approx \sum_{n=0}^{\infty} \frac{f^{(n)}(0)}{n!} x^n$$

$$\left.\begin{aligned} E^{(1)}(V) &= -4E_c \frac{1}{N_F V} e^{-2/N_F V} \\ E^{(2)}(V) &= -4E_c \frac{1}{N_F V^2} e^{-2/N_F V}\left(\frac{2}{N_F V} - 1\right) \\ E^{(3)}(V) &= -8E_c \frac{1}{N_F V^3} e^{-2/N_F V}\left(1 - \frac{4}{N_F V} + \frac{2}{N_F^2 V^2}\right) \end{aligned}\right\} E^{(n)}(0) \text{ undefined } \ddot{\frown}$$

?

Try again:

$$e^x \text{ s.t. } x=0 \approx \sum_{n=0}^{\infty} \frac{x^n}{n!}$$

$$e^{-2/N_F V} \approx \sum_{n=0}^{\infty} \frac{\left(\frac{-2}{N_F V}\right)^n}{n!}$$

$$\boxed{E(V) \approx 2E_F - 2E_C \sum_{n=0}^{\infty} \frac{1}{n!}\left(\frac{-2}{N_F V}\right)^n}$$

$\boxed{14.2}$ $V = n \frac{h}{2e} f$

$R_H = \frac{1}{n} \frac{h}{e^2}$

$\hookrightarrow V = I R_H$

$\hookrightarrow I = \frac{V}{R_H} = \frac{n \frac{\cancel{h}}{2\cancel{e}} f}{\frac{1}{n} \frac{\cancel{h}}{e^{\cancel{2}}}} = \frac{1}{2} n^2 f e$

$IV = mgv$

$\hookrightarrow \frac{1}{2} n^2 f \cancel{e} \cdot n \frac{h}{2\cancel{e}} f = mgv$

$$\boxed{\frac{1}{4} n^3 f^2 h = mgv}$$

$\boxed{14.3}$ $\Phi_0 = 2.07 \times 10^{-7}\ G\cdot cm^2$

$1\,cm^2 = \pi r_{squid}^2$

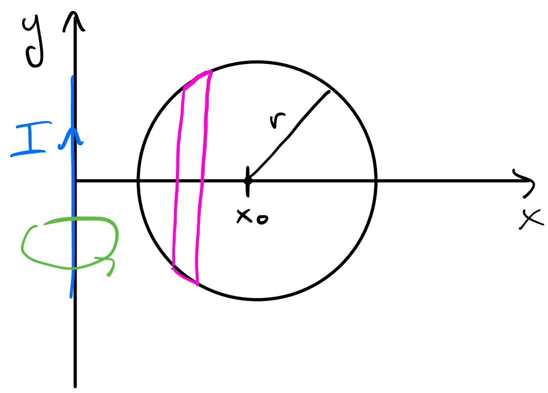
↳ $r_{squid} = .56\,cm = .0056\,m$

Magnetic field of a current-carrying wire:

Ampere's law: $\oint \vec{B}\cdot d\vec{s} = \mu_0 I_{enclosed}$

$B \cdot 2\pi r = \mu_0 I$

$B = \frac{\mu_0 I}{2\pi r}$



$(x-x_0)^2 + y^2 = r^2$

$y = \pm\sqrt{r^2 - (x-x_0)^2}$

$B(x) = \frac{\mu_0 I}{2\pi x}$

$\Phi = \iint_A B(x)\, dA$

$= \int_{x_0-r}^{x_0+r} \frac{\mu_0 I}{2\pi x} \int_{-\sqrt{r^2-(x-x_0)^2}}^{+\sqrt{r^2-(x-x_0)^2}} dy\, dx$

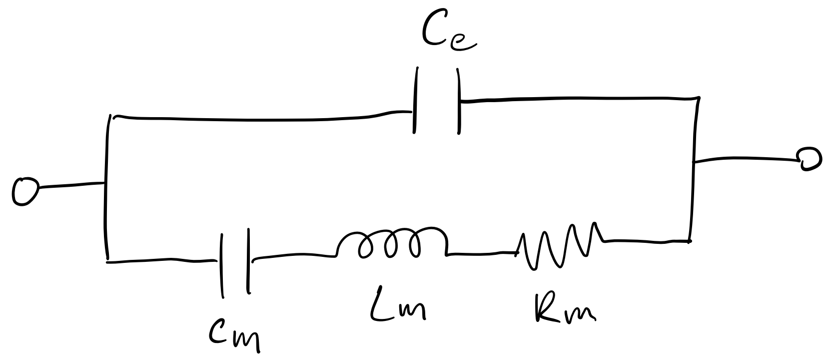
$= \int_{x_0-r}^{x_0+r} \frac{\mu_0 I}{\cancel{2}\pi x} \cdot \cancel{2}\sqrt{r^2-(x-x_0)^2}\, dx$

$= \frac{\mu_0 I}{\pi} \int_{x_0-r}^{x_0+r} \frac{\sqrt{r^2-(x-x_0)^2}}{x}\, dx$

$= \frac{\mu_0 I}{\pi}\sqrt{r^2-x_0^2}\,\underbrace{\left[\ln(r^2-rx_0) - \ln(-r^2+rx_0)\right]}_{\ln\left(\frac{r^2-rx_0}{-(r^2-rx_0)}\right) = \ln(-1)\ ?} + \pi x_0$

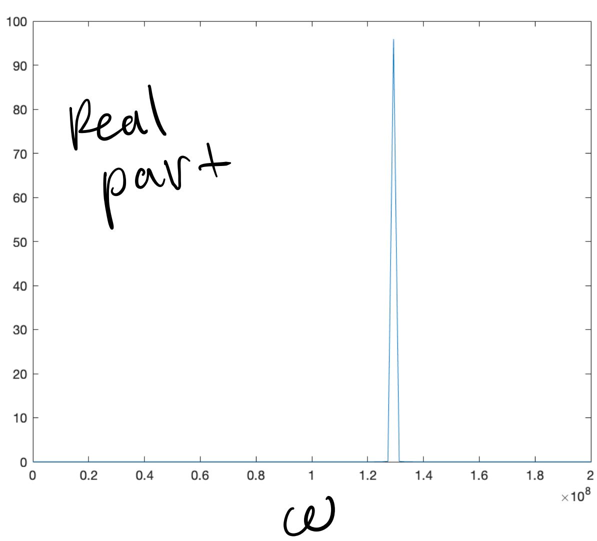
Solve $\Phi(x_0) = \Phi_0$ for $I = 1A$ and $r = .0056\ m$

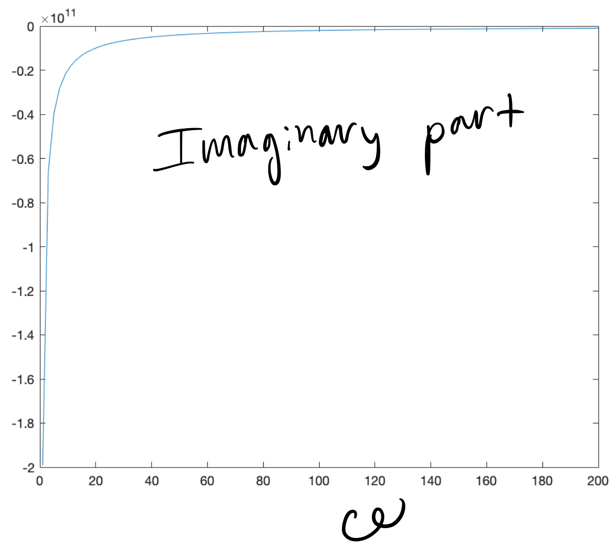
$\boxed{14.4}$



$$Z = \frac{1}{j\omega C_e} \parallel \left(\frac{1}{j\omega C_m} + j\omega L_m + R_m\right)$$

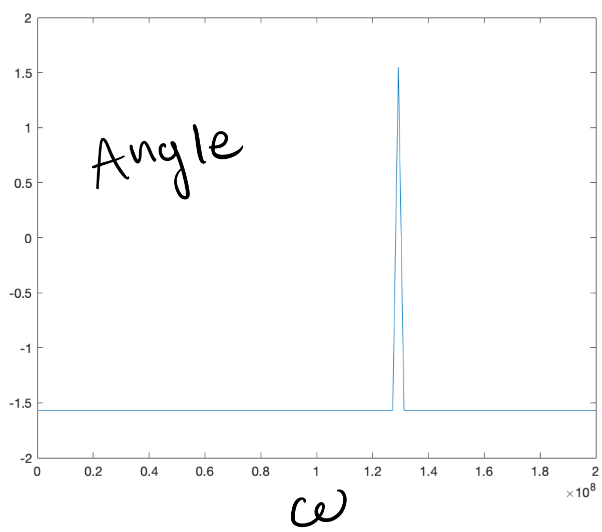
$$Z = \cfrac{1}{j\omega C_e + \cfrac{1}{\left(\frac{1}{j\omega C_m} + j\omega L_m + R_m\right)}}$$





Resonance $= \frac{1}{\sqrt{L_m C_m}} = 1.3 \times 10^8 \ \frac{rad}{s}$

Smaller capacitance dominates



$\boxed{14.5}$ Harrison chronometer: 1 s/day accuracy

Based on earth circumference = 21641 n.m.

↳ 1° = 60 n.m.

Earth revolves @ 360°/24 hrs → 1° = 4 min

∴ 4 min error = 60 n.m. → 1 min error = 15 n.m.

∴ 1 month = 30.44 days → 30.44 s error = 0.507 min error

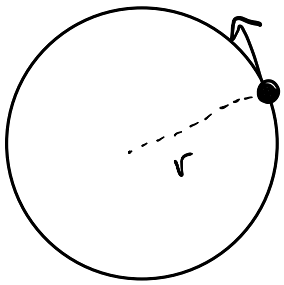
→ $\boxed{7.61 \text{ n.m. error}}$

Atomic clock: 10^{-12} s/s = 8.64×10^{-8} s error per day

1 month = 30.44 days → 2.63×10^{-6} s error = 4.38×10^{-8} min error

→ $\boxed{6.58 \times 10^{-7} \text{ n.m. error}}$

$\boxed{14.6}$



$r = 2.018 \times 10^7\,m + 6.38 \times 10^6\,m = 2.66 \times 10^7\,m$

a) $a = \frac{v^2}{r} = \frac{GM}{r^2}$

$\hookrightarrow v = \sqrt{\frac{GM}{r}} = \boxed{3871\ m/s}$

b) $2\pi \cdot 2.66 \times 10^7\,m = v \cdot T$

$T = 43175\,s = \boxed{12\ hours}$

c) ?

d) Slower on earth

$$\frac{t_{earth}}{t_{sat}} = \frac{1 - \frac{GM}{6.38 \times 10^6\,m \cdot c^2}}{1 - \frac{GM}{2.66 \times 10^7\,m \cdot c^2}} = .99999999947158$$

2.28×10^{-5} s error per 12 hrs