# Physics 30 – Lesson 4
# Graphing for Fun and Profit

/ 49

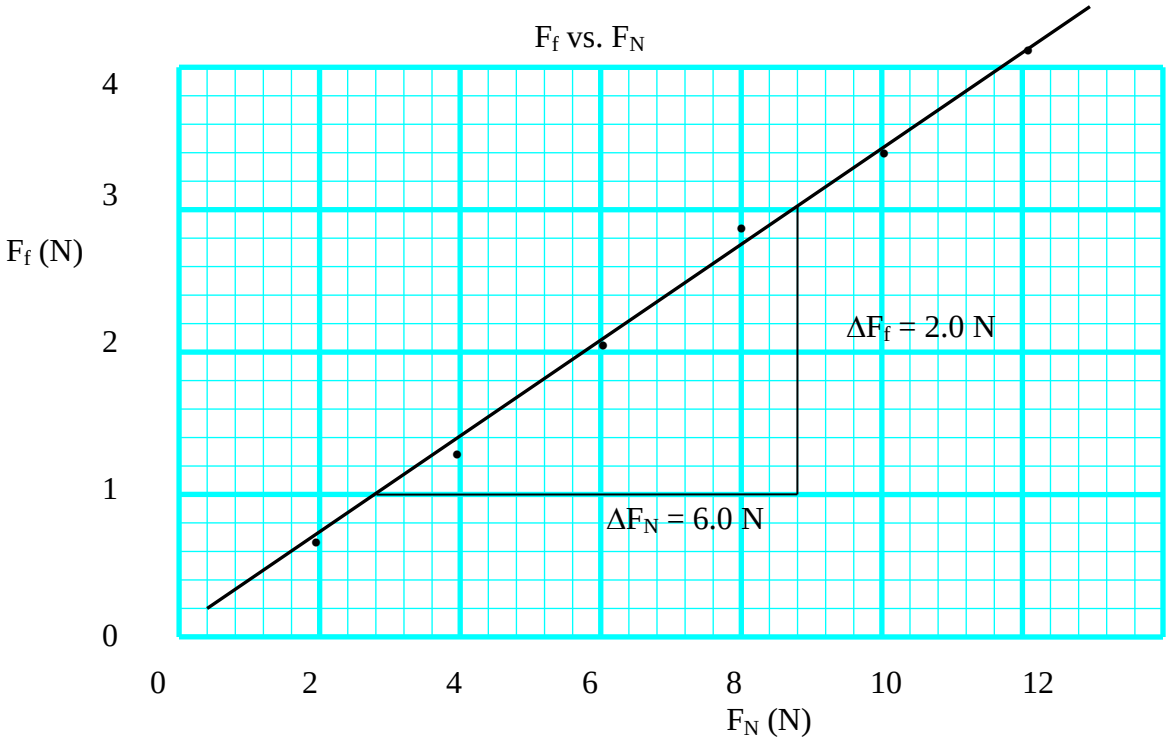
## Practice problems

1)

| $F_N$ (N) | $F_f$ (N) |
|---|---|
| **2.0** | **0.72** |
| **4.0** | **1.3** |
| **6.0** | **2.1** |
| **8.0** | **2.9** |
| **10.0** | **3.4** |
| **12.0** | **4.2** |

$$F_f = \mu F_N$$

$$\mu = \frac{\Delta F_f \leftarrow rise}{\Delta F_N \leftarrow run}$$




$$slope = \frac{\Delta F_f}{\Delta F_N} = \frac{2.0N}{6.0N} = 0.33$$

$$\boxed{\mu = 0.33}$$

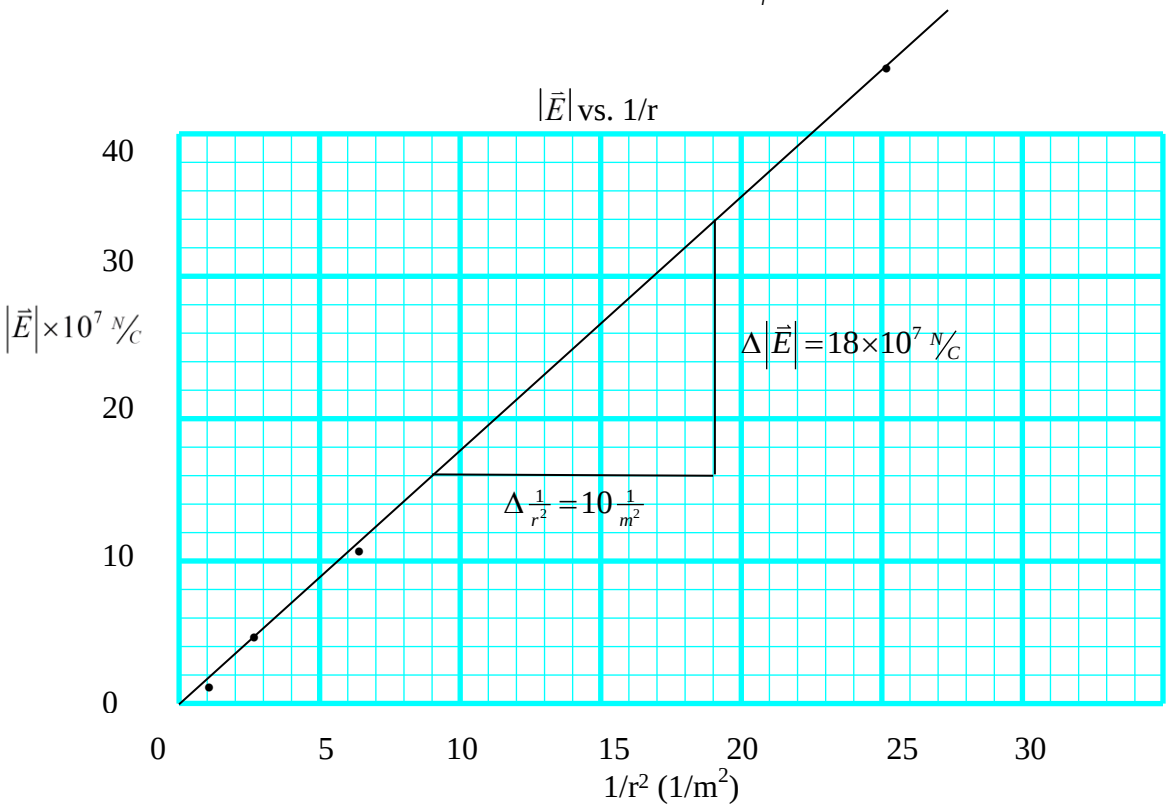
2)

| r(m) | $1/r^2$ $(1/m^2)$ | $\lvert\vec{E}\rvert(\times 10^7\ N/C)$ |
|---|---|---|
| **0.20** | **25** | **45** |
| **0.40** | **6.25** | **11** |
| **0.60** | **2.8** | **5.0** |
| **0.80** | **1.6** | **2.8** |
| **1.0** | **1.0** | **1.8** |

$$\lvert\vec{E}\rvert = k\frac{q}{r^2}$$

$$\lvert\vec{E}\rvert = kq\frac{1}{r^2}$$

$$\frac{rise \rightarrow \lvert\vec{E}\rvert}{run \rightarrow \frac{1}{r^2}} = kq \leftarrow slope$$




$$slope = \frac{rise}{run} = \frac{18\times 10^7\ N/C}{10\left(\frac{1}{m^2}\right)} = 1.8\times 10^7\ N\cdot m^2/C$$

$$slope = kq$$

$$k = \frac{slope}{q} = \frac{1.8\times 10^7\ N\cdot m^2/C}{2.0\times 10^{-3} C} = \boxed{9.0\times 10^9\ \frac{N\cdot m^2}{C^2}}$$

$$\%\text{error} = \frac{\text{theoretical} - \text{experimental}}{\text{theoretical}}$$

$$\%\text{error} = \frac{8.99\times 10^9 - 9.0\times 10^9}{8.99\times 10^9}$$

$$\%\text{error} = 0.1\%$$

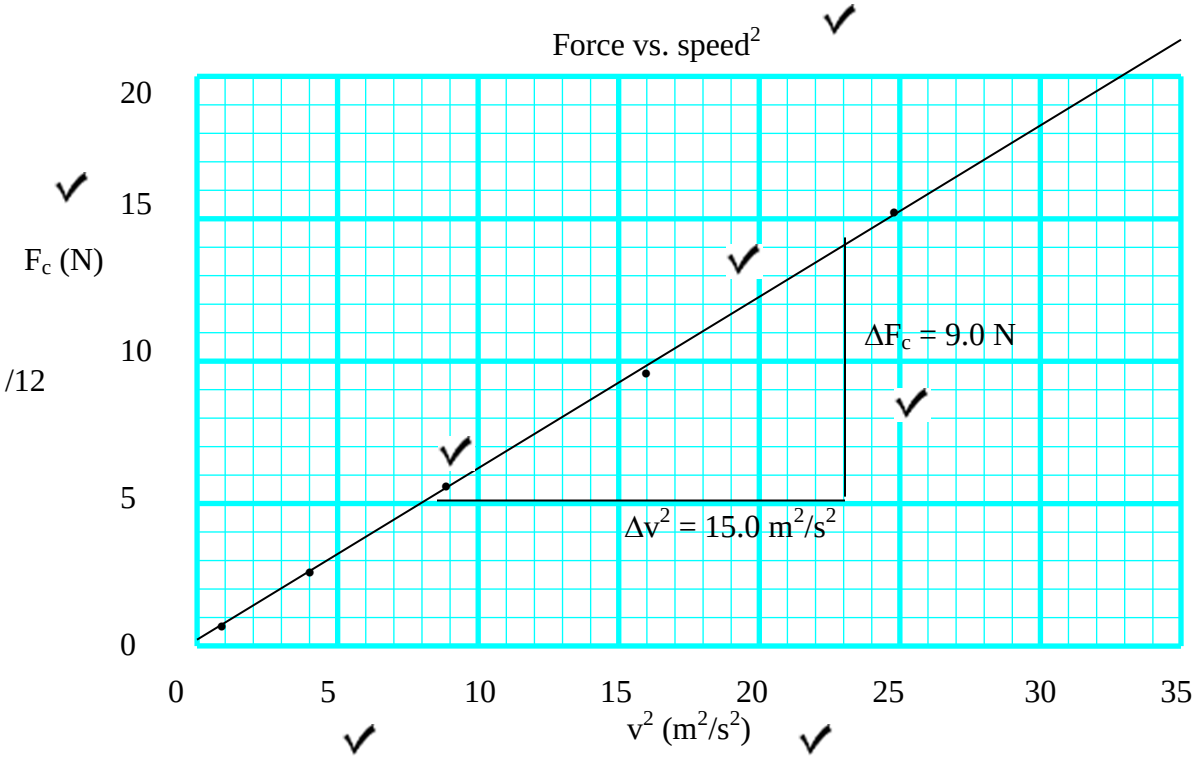
## Assignment

1)

| Force (N) | Speed (m/s) | $v^2$ ($m^2/s^2$) |
|---|---|---|
| **0.60** | **1.0** | **1.0** |
| **2.40** | **2.0** | **4.0** |
| **5.40** | **3.0** | **9.0** |
| **9.60** | **4.0** | **16** |
| **15.0** | **5.0** | **25** |

$$F_c = \frac{mv^2}{r}$$

$$slope \rightarrow \frac{m}{r} = \frac{F_c \leftarrow rise}{v^2 \leftarrow run}$$




/12

$$slope = \frac{\Delta F_c}{\Delta v^2} = \frac{9.0N}{15.0\,{}^{m^2}\!/_{s^2}} = 0.60\frac{N}{{}^{m^2}\!/_{s^2}}$$

$$\frac{N}{{}^{m^2}\!/_{s^2}} = \frac{{}^{kg\,m}\!/_{s^2}}{{}^{m^2}\!/_{s^2}} = \frac{kg}{m}$$

$$slope = \frac{m}{r}$$

$$m = r \cdot slope = 1.25m(0.60\,{}^{kg}\!/_{m})$$

$$\boxed{m = 0.75kg}$$

2)

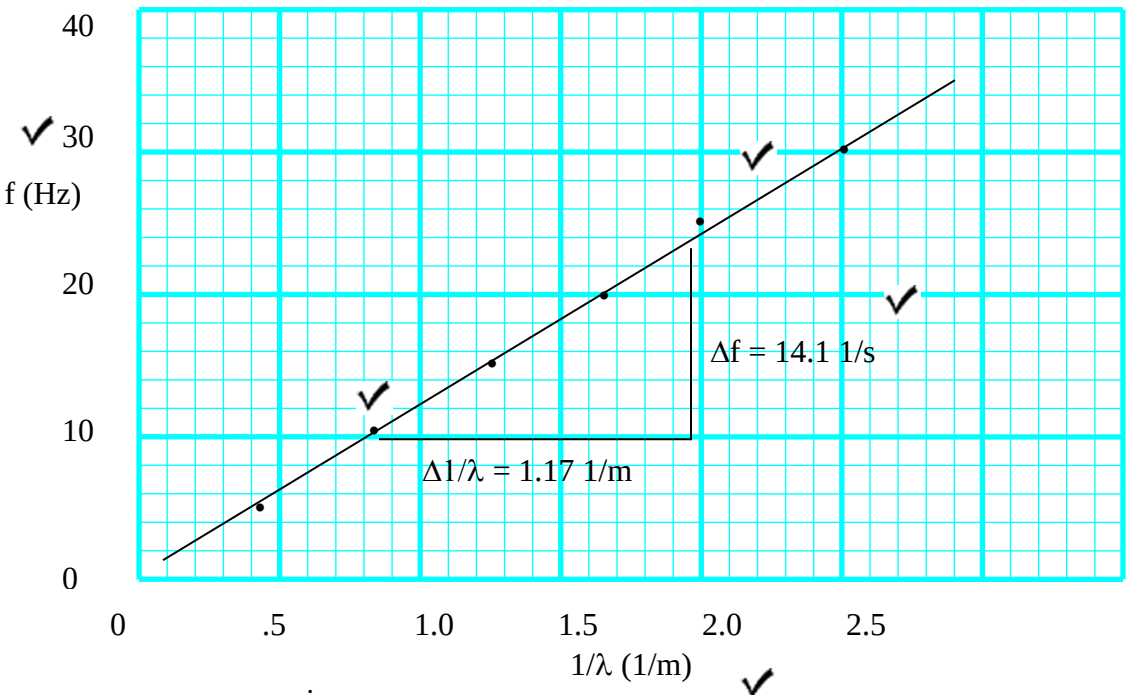
Note inverse relation ✓

| f (Hz) | λ (m) | 1/λ (1/m) |
|---|---|---|
| **5** | **2.4** | **0.42** |
| **10** | **1.2** | **0.83** |
| **15** | **0.8** | **1.25** |
| **20** | **0.6** | **1.67** |
| **25** | **0.5** | **2.0** |
| **30** | **0.4** | **2.5** |

$v = f\lambda$ ✓

$slope \rightarrow v = \frac{f \leftarrow rise}{\frac{1}{\lambda} \leftarrow run}$

Frequency vs. 1/ λ ✓




✓ ✓ ✓ ✓ ✓

/10

$v = slope = \frac{rise}{run}$

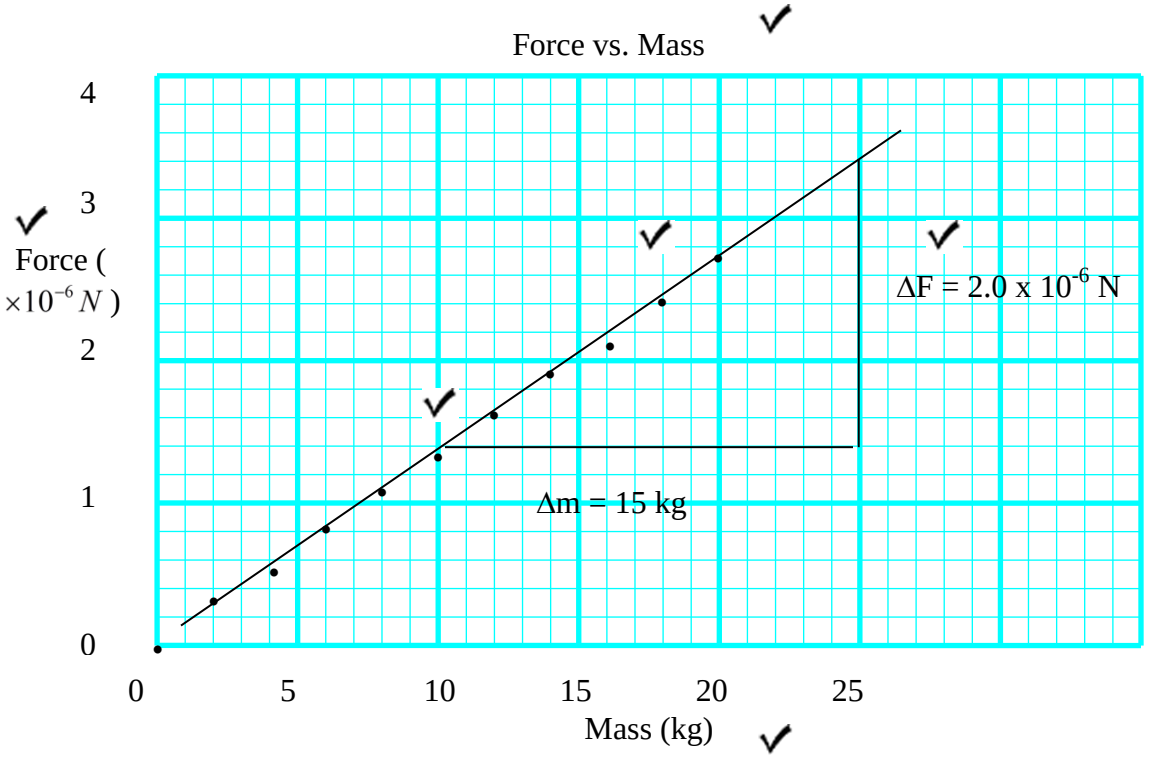
$v = \frac{14.1\,1/s}{1.17\,1/m}$ ✓

$\boxed{v = 12\,m/s}$ ✓

3)

$$F_g = \frac{Gm_1m_2}{r^2}$$ ✓

$$slope \rightarrow \frac{Gm_1}{r^2} = \frac{F_g}{m_2} \quad \begin{matrix} \leftarrow rise \\ \leftarrow run \end{matrix}$$




/13

$$slope = \frac{\Delta F}{\Delta m} = \frac{2.0\times10^{-6}\,N}{15kg} = 1.33\times10^{-7}\,\frac{N}{kg}$$

$$slope = \frac{Gm_1}{r^2}$$

$$G = \frac{slope \cdot r^2}{m_1} = \frac{1.37\times10^{-7}\,{}^{N}\!/_{kg}\,(0.10m)^2}{20kg} = \boxed{6.67\times10^{-11}\,\frac{N\cdot m^2}{kg^2}}$$

$$\%error = \frac{\text{experimental} - \text{theoretical}}{\text{theoretical}}$$

$$\%error = \frac{6.67\times10^{-11} - 6.67\times10^{-11}}{6.67\times10^{-11}}$$

$$\%error = 0\%$$

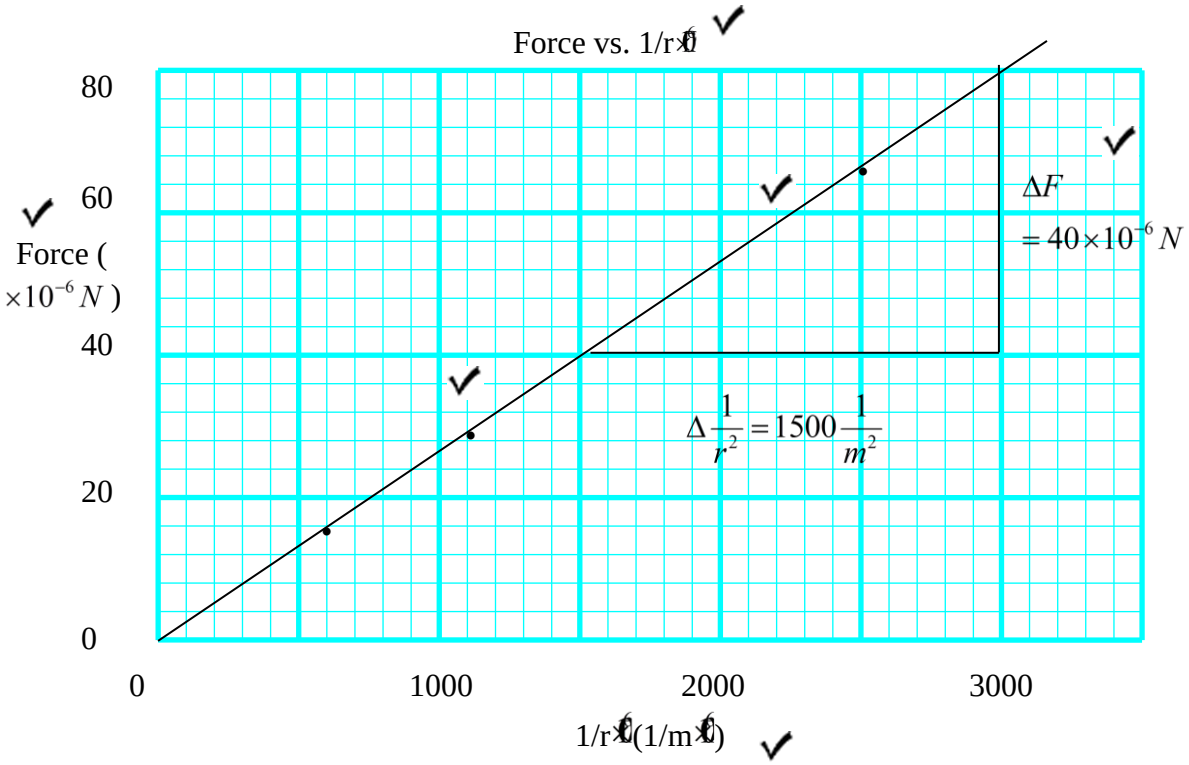
4)

| r(m) | $1/r^2$ | $F(\times 10^{-6} N)$ |
|---|---|---|
| **0.02** | **2500** | **66.7** |
| **0.03** | **1111** | **29.6** |
| **0.04** | **625** | **16.7** |
| **0.05** | **400** | **10.7** |
| **0.06** | **278** | **7.41** |
| **0.07** | **204** | **5.44** |
| **0.08** | **145** | **4.17** |
| **0.09** | **123** | **3.29** |
| **0.10** | **100** | **2.67** |
| **0.11** | **83** | **2.20** |
| **0.12** | **69** | **1.85** |

$$F_g = \frac{Gm_1m_2}{r^2}$$

$$\frac{rise \rightarrow}{run \rightarrow} \frac{F_g}{\frac{1}{r^2}} = Gm_1m_2 \leftarrow slope$$

/14




$$slope = \frac{rise}{run} = \frac{40 \times 10^{-6} N}{1500\left(\frac{1}{m^2}\right)} = 2.67 \times 10^{-8} N \cdot m^2$$

$$slope = Gm_1m_2$$

$$G = \frac{slope}{m_1m_2} = \frac{2.67 \times 10^{-8} N \cdot m^2}{(20kg)(20kg)} = \boxed{6.67 \times 10^{-11} \frac{N \cdot m^2}{kg^2}}$$

$$\%error = \frac{\text{theoretical} - \text{experimental}}{\text{theoretical}}$$

$$\%error = \frac{6.67 \times 10^{-11} - 6.67 \times 10^{-11}}{6.67 \times 10^{-11}}$$

$$\%error = 0\%$$