SPH4U1 Graphing Assignment

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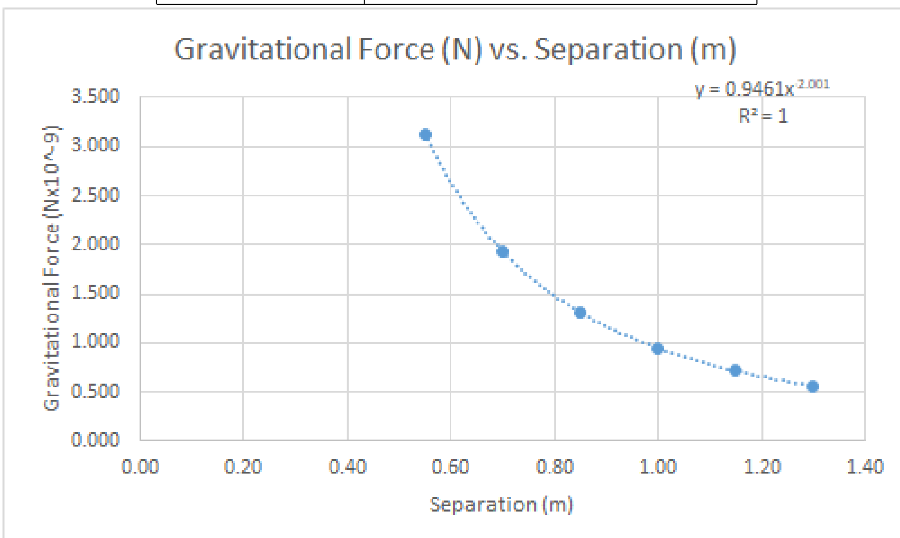
All explanations at the bottom.

1 Part A

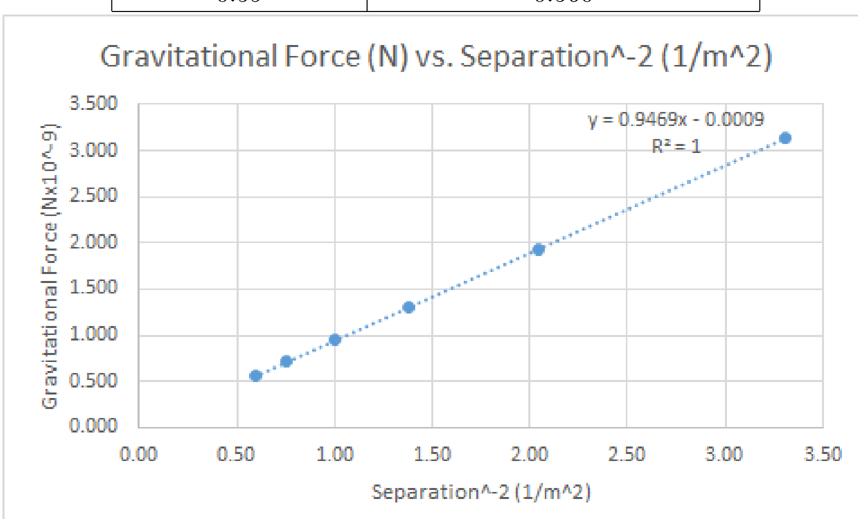
Original table of data:

Separation (m)	Gravitational Force (N $\times 10^{-9}$)
0.55	3.130
0.70	1.930
0.85	1.310
1.00	0.946
1.15	0.715
1.30	0.560



Curve straightened table of data:

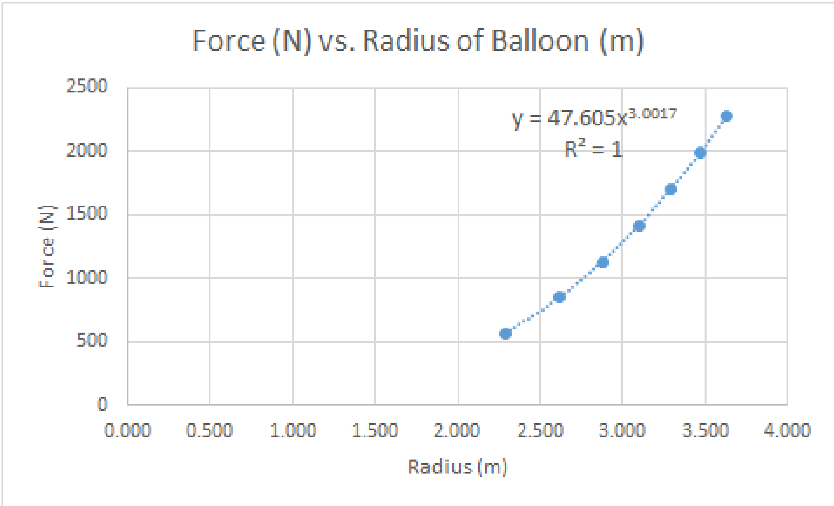
Separation^{-2} (m^{-2})	Gravitational Force (N $\times 10^{-9}$)
3.31	3.130
2.04	1.930
1.38	1.310
1.00	0.946
0.76	0.715
0.59	0.560



2 Part B

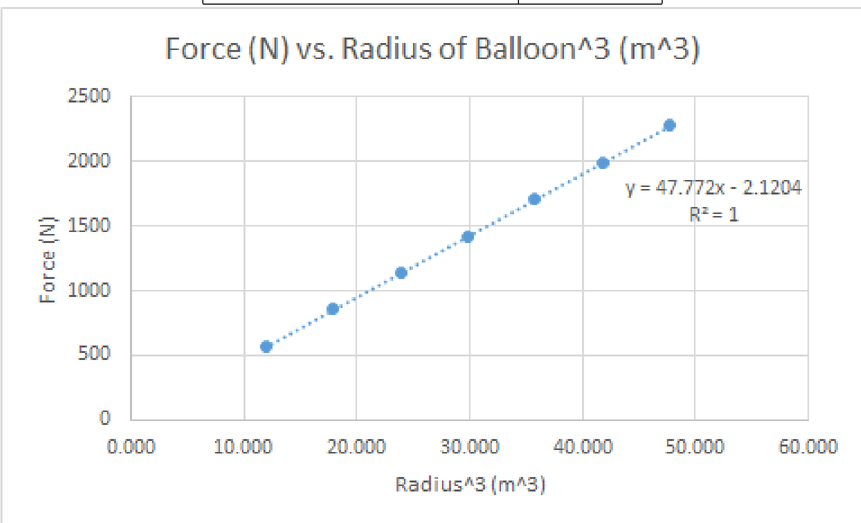
Original table of data:

Radius of Balloon (m)	Force (N)
2.285	569
2.616	855
2.879	1135
3.102	1422
3.296	1709
3.470	1993
3.628	2281



Curve straightened table of data:

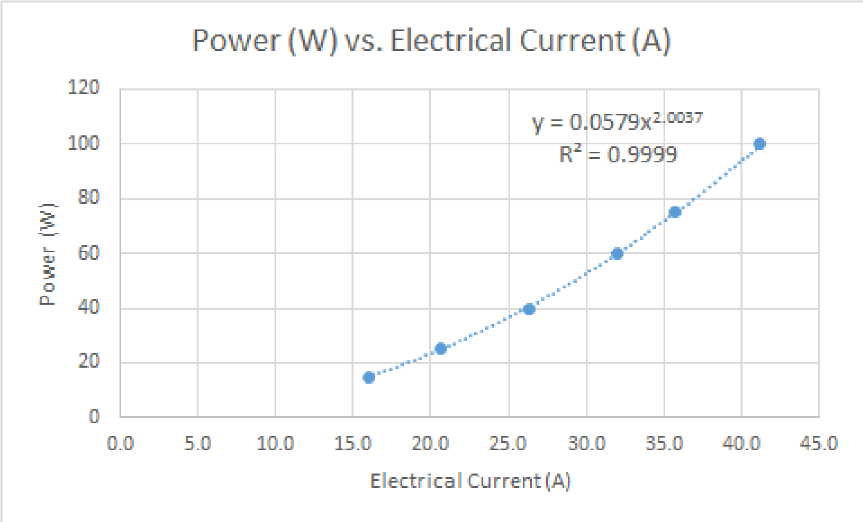
Radius of Balloon^3 (m^3)	Force (N)
11.930	569
17.902	855
23.863	1135
29.849	1422
35.806	1709
41.782	1993
47.753	2281



3 Part C

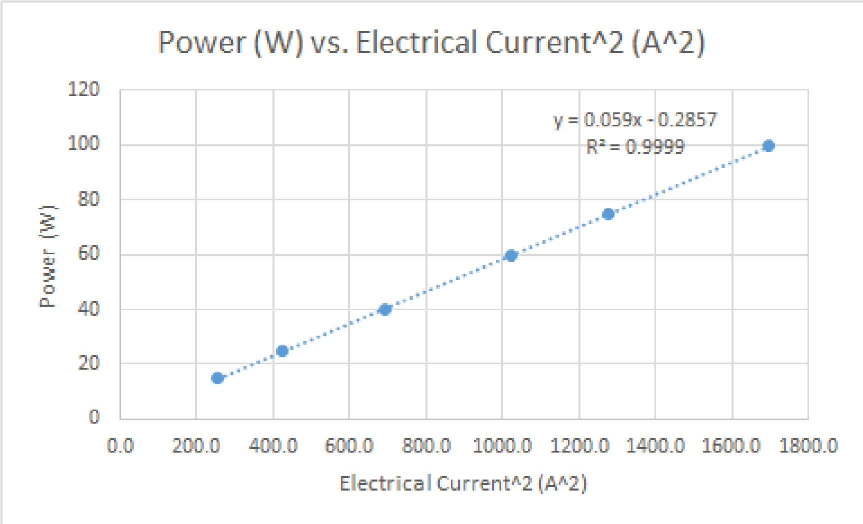
Original table of data:

Electrical Current (A)	Power (W)
16.0	15
20.6	25
26.3	40
32.0	60
35.7	75
41.2	100



Curve straightened table of data:

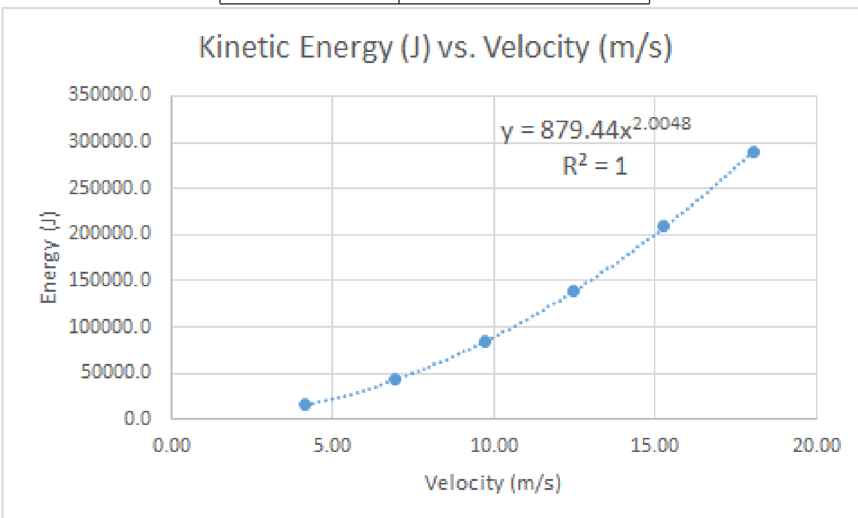
Electrical Current^2 (A^2)	Power (W)
256.0	15
424.4	25
691.7	40
1024.0	60
1274.5	75
1697.4	100



4 Part D

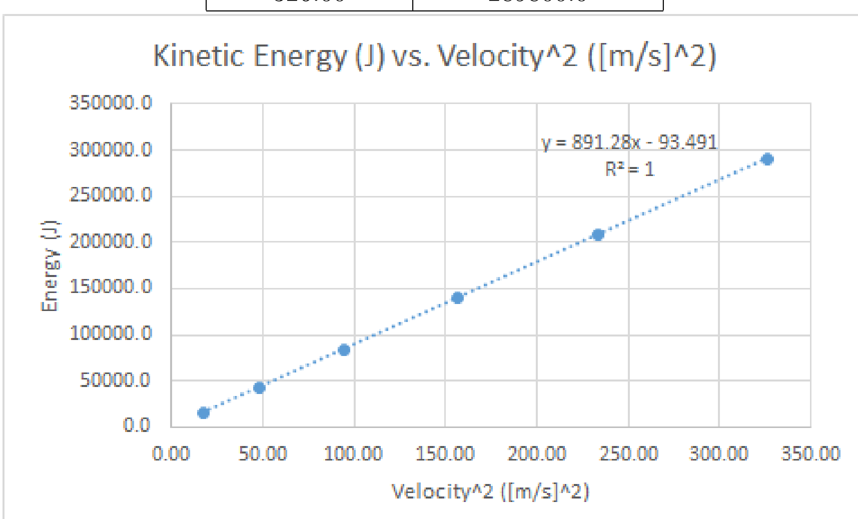
Original table of data:

Velocity ($\frac{m}{s}$)	Kinetic Energy (J)
4.17	15400.0
6.94	42700.0
9.72	83800.0
12.50	139400.0
15.28	208900.0
18.06	289800.0



Curve straightened table of data:

Velocity^2 $\left(\frac{m}{s}\right)^2$	Kinetic Energy (J)
17.36	15400.0
48.23	42700.0
94.52	83800.0
156.25	139400.0
233.41	208900.0
326.00	289800.0



5 Explanations

5.1 Part A

Let d = separation distance (in meters)

$$F \propto \frac{1}{d^2}$$

$$F = \frac{k}{d^2}$$

$$F = ma = \frac{kg \times m}{s^2}$$

$$\frac{kg \times m}{s^2} = \frac{k}{m^2}$$

$$k = \frac{kg \times m^3}{s^2}$$

The original table had separation in centimeters (cm), so it was converted into meters (m) to ensure only standard SI units are compared. The original graph shows an inverse quadratic relationship between sphere separation and the gravitational force. A linear relationship exists between them with the equation: $y = 0.9469x - 0.0009$, where x represents separation^{-2} in meters (m^{-2}), and y is the gravitational force in Newtons (N). In the curve-straightened graph, the y-intercept indicates at 0 m^{-2}, there is a force of -0.0009 N.

In the modified graph, the value of the proportionality constant (k) was determined to be 0.9469. The units for k can also be determined:

5.2 Part B

In the original graph, there is a cubic relationship between the radius of the balloon and the buoyant force. A linear relationship can be represented with $y = 47.772x - 2.1204$, where x is the radius of the balloon^3 in meters (m^3) and y is the buoyant force in Newtons (N). The curve-straightened graph indicates at a radius of 0 m^3, there is a negative force of 2.1204 N.

The proportionality constant (k) value was determined to be 47.772 according to the modified graph. The units of k were determined:

Let r represent the radius (in meters)

$$F \propto r^3$$

$$F = k \times r^3$$

$$F = ma = \frac{kg \times m}{s^2}$$

$$\frac{kg \times m}{s^2} = k \times m^3$$

$$k = \frac{\frac{kg \times m}{s^2}}{m^3}$$

$$k = \frac{kg}{m^2 \times s^2}$$

5.3 Part C

According to the original graph, there is a quadratic relationship between electrical current and power. This can be linearized into $y = 0.059x - 0.2857$, where x is the electrical current^2 in amperes (A^2) and y is power in watts (W).

The proportionality constant (k) value was determined to be 0.059 according to the modified graph. The units of k were determined:

$$P \propto I^2$$
$$P = k \times I^2$$

Note: Power is in Watts, and Current is in Amps.

$$W = k \times A^2$$
$$k = \frac{W}{A^2}$$
$$P = I \times V, \ V = I \times R$$
$$\therefore P = R \times I^2$$
$$k \times I^2 = R \times I^2$$
$$k = R = \frac{P}{I^2} = \frac{W}{A^2}$$

where k is the resistance in ohms.

Since $P = R \times I^2$, if R, the resistance, is constant, then power would be directly proportional to the current. In the curve-straightened graph, the y-intercept is -0.2857, meaning that when the current is 0 A, the power is -0.2857 W. According to the power equation, if $I = 0A$ then power should be $0W$, indicating there is slight error between the data values.

5.4 Part D

The original data table gave values of velocity in $\frac{\mathrm{km}}{\mathrm{h}}$ and kinetic energy in kJ. These are not in standard SI units, so kinetic energy was converted into J and velocity was converted into $\frac{\mathrm{m}}{\mathrm{s}}$. Since the velocity had to be rounded twice, once through unit conversion and once through squaring, the values were not as accurate and resulted in different k values in each both the original and modified graphs.

In the original graph, there was an quadratic relationship between the velocity and kinetic energy. A linear relationship can be represented by $y = 891.28x - 93.491$, where x is the velocity^2 in meters per second ($\frac{\mathrm{m}^2}{\mathrm{s}^2}$) and y is the kinetic energy in joules (J).

The proportionality constant (k) value was determined to be 891.28 according to the modified graph. The units of k were determined:

$$E_k \propto v^2$$
$$E_k = k \times v^2$$
$$E_k = J = F \times d = N \times m$$
$$= kg \times \frac{m}{s^2} \times m = \frac{kg \times m^2}{s^2}$$

Note: v = m/s

$$\frac{kg \times m^2}{s^2} = k \times \frac{m}{s}^2$$

$$\frac{kg \times m^2}{s^2} = k \times \frac{m^2}{s^2}$$

$$k = \frac{\frac{kg \times m^2}{s^2}}{\frac{m^2}{s^2}}$$

$$k = kg$$

Since the formula for kinetic energy is $E_k = \frac{1}{2}mv^2$, it would make sense for the proportionality constant to be the mass.

In the modified graph, the y-intercept was determined to be -93.491. This means that when velocity is 0, there would still be kinetic energy of a magnitude of 93.491 J. However, there should be no kinetic energy when an object is not moving, so that implies that there is error from either the data values and/or rounding.