Masses 1 and 2 are placed as shown in the diagram.

\[ M_1 = 30,000,000 \text{ g} \quad M_2 = 5,000,000 \text{ g} \]

NOTE: Vector variables are in **bold** while a magnitude is the same variable without bold.

Newton's Universal Gravitation Law:  
\[ F_{21} = G \frac{m_1 m_2}{r_{12}^2} \quad \text{where} \quad G = 6.67 \times 10^{-11} \text{ m}^2 \text{N/kg}^2 \]

What units are the coordinates given in (no abbreviations)?

What units are the masses given in (no abbreviations)?

Express both masses in Scientific Notation:  
\[ M_1 = \text{__________} \quad M_2 = \text{__________} \]

How many dimensions in this problem?

How many components will each vector have?
Specify the cartesian components of each of the following vectors:

<table>
<thead>
<tr>
<th>Dimension</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$R_1$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$R_2$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$R_2 - R_1$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$R_1 + R_2$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Specify the formulas for the polar components of each of the following position vectors:

<table>
<thead>
<tr>
<th>Dimension</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$R_1$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$R_2$</td>
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</tr>
<tr>
<td>$R_2 - R_1$</td>
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<td></td>
</tr>
<tr>
<td>$R_2 + R_1$</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Does it truly matter where you draw a vector (i.e. - where the “tail” is located)?

What properties of a vector actually matter?

Sketch all four vectors on a coordinate grid given on the following page with their “tails” at the origin.

Sketch vectors $R_1$, $R_2$ and $R_2 - R_1$ on a coordinate grid on the following page in a way that makes their relationship clear.

Sketch vectors $R_1$, $R_2$ and $R_1 + R_2$ on a coordinate grid on the following page in a way that makes their relationship clear.
Calculate the value of $F_{21}$ showing your work, i.e. -

$F_{21} = \text{formula with problem variables} = \text{formula with values and units} = \text{result with units}$

Did you have to do anything with the original values given to make the units come out right? If so, what?

By what factor does $F_{21}$ change if $R_1$ and $R_2$ are doubled?

$M_1$ is doubled? $M_1$ and $M_2$ are both doubled?

Is the force zero at any particular point along the line between the two masses?

If so, is the point closer to $M_1$ or $M_2$?
The mass $M$ is suspended in *equilibrium* from a ceiling by very thin, very light strings.

What is meant by “equilibrium”?

Because of this, what can we conclude about the forces at any given point in the structure?

What is meant by “tension” in such problems?

What is the angle $BAC$?

Draw a Free-Body Diagram at M, A, B and C.

What is the tension along string $MA$ (a numerical value with units)?

Show how to solve for the tension in the other two strings.