```
% Kathryn Atherton
% Margaret Hegwood
% Audrey Conrad
% Kristen Palmer
% ABE 301 Extra Credit M&M Model

clc;
clear;

fprintf('What is being requested?\n     Number of M&Ms in a fun-sized
 bag.\n');
fprintf('Identify parameters and variables. Give each a symbolic name.
\n');
fprintf('     Volume of bag: b\n');
fprintf('     Volume of M&M: m\n');
fprintf('     Number of M&Ms: n\n');
fprintf('Identify fundamental relationships between parameters.\n');
fprintf('     b/m = n\n\n');

fprintf('Iteration 1:\n');
fprintf('Assumptions:\n');
fprintf('     The shape of the bag is a cuboid with a face that is 8
 cm by 8 cm.\n');
fprintf('     The shape of the M&M is a sphere with a radius of 0.5
 cm.\n');
fprintf('     The height of the bag is equal to the diameter of one
 M&M.\n');
fprintf('     There is no empty space in the bag.\n');

b_length = 8; % cm, estimation based on looking at bag
m_radius = 0.5; % cm, estimation found on class slides from 1/10
 lecture

b = b_length * b_length * 2 * m_radius;
m = (4 / 3) * pi * (m_radius ^ 3);
n = b / m;

fprintf('%d M&Ms can fit in the bag.\n\n', round(n));

fprintf('Iteration 2:\n');
fprintf('Assumptions:\n');
fprintf('     The shape of the bag is a cuboid with a face that is 8
 cm by 8 cm.\n');
fprintf('     The shape of the M&M is an oblate spheroid with a short
 radius of 0.3 cm and a long radius of 0.6 cm.\n');
fprintf('     The height of the rectangular prism is equal to the
 shorter diameter of the M&M.\n');
fprintf('     There is no empty space in the bag.\n');

m_radius_short = 0.3; % cm, estimation found on class slides from 1/10
 lecture
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m_radius_long = 0.6; % cm, estimation found on class slides from 1/10
 lecture

b = b_length * b_length * 2 * m_radius_short;
m = (4 / 3) * pi * (m_radius_long ^ 2) * (m_radius_short); % formula
 found on class slides from 1/10 lecture
n = b / m;

fprintf('%d M&Ms can fit in the bag.\n\n', round(n));

fprintf('Iteration 3:\n');
fprintf('Assumptions:\n');
fprintf('     The shape of the bag is a cuboid with a face that is 8
 cm by 8 cm.\n');
fprintf('     The shape of the M&M is an oblate spheroid with a short
 radius of 0.3 cm and a long radius of 0.6 cm.\n');
fprintf('     The height of the rectangular prism is equal to the
 shorter diameter of the M&M.\n');
fprintf('     Void space exists in the bag.\n');
fprintf('     The M&Ms are packed in a hexogonal fasion in one flat
 layer (hexoganal planar packing pattern).\n')

d = 0.9069; %  regular hexagonal lattice packing density, Axel Thue
 Theorem (http://math.stmarys-ca.edu/wp-content/uploads/2017/07/
Roshni-Mistry.pdf)
n = b / (4 * pi * (m_radius_long ^ 2) * (m_radius_short) / d);

fprintf('%d M&Ms can fit in the bag.\n\n', round(n));

fprintf('Iteration 4:\n');
fprintf('Assumptions:\n');
fprintf('     The shape of the bag is a rectangular prism with a face
 that is 7.62 cm by 9.525 cm.\n');
fprintf('     The shape of the M&M is an oblate spheroid with a short
 radius of 0.3 cm and a long radius of 0.6 cm.\n');
fprintf('     The height of the rectangular prism is equal to the
 shorter diameter of the M&M.\n');
fprintf('     Void space exists in the bag.\n');
fprintf('     The M&Ms are packed in a hexogonal fasion in one flat
 layer (hexoganal planar packing pattern).\n')

b_length = 7.62; % cm, candywarehouse.com (https://
www.candywarehouse.com/peanut-mms-candy-fun-size-packs-5lb-bag/)
b_width = 9.525; % cm, candywarehouse.com (https://
www.candywarehouse.com/peanut-mms-candy-fun-size-packs-5lb-bag/)

b = b_length * b_width * 2 * m_radius_short;
n = b / (4 * pi * (m_radius_long ^ 2) * (m_radius_short) / d);

fprintf('%d M&Ms can fit in the bag.\n\n', round(n));

fprintf('Iteration 5:\n');
fprintf('Assumptions:\n');
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fprintf('     The shape of the bag is a "pillow" with a face that is
 7.62 cm by 9.525 cm.\n');
fprintf('     The shape of the M&M is an oblate spheroid with a short
 radius of 0.3 cm and a long radius of 0.6 cm.\n');
fprintf('     Void space exists in the bag.\n');
fprintf('     The M&Ms are packed in a 3-D hexogonal fasion.\n');

d_full = 1.209; % estimation found on class slides from 1/10 lecture

b = (b_width ^ 3) * (b_length / (pi * b_width) - 0.142 * (1 - 10 ^ (-1
 * b_length / b_width))); % Robin, 2004 (http://mathworld.wolfram.com/
PaperBag.html)
n = b / (4 * pi * (m_radius_long ^ 2) * (m_radius_short) / d_full);

fprintf('%d M&Ms can fit in the bag.\n\n', round(n));

fprintf('Iteration 6:\n');
fprintf('Assumptions:\n');
fprintf('     The shape of the bag is a "pillow" with a face that is
 7.62 cm by 9.525 cm.\n');
fprintf('     However, 0.7 centimeters on each side of the
 aforementioned face is used to seal the bag and does not contribute
 to the volume.\n');
fprintf('     The shape of the M&M is an oblate spheroid with a short
 radius of 0.3 cm and a long radius of 0.6 cm.\n');
fprintf('     The height of the rectangular prism is equal to the
 shorter diameter of the M&M.\n');
fprintf('     Void space exists in the bag.\n');
fprintf('     The M&Ms are packed in a 3-D hexogonal fasion.\n');

b_length = b_length - 0.7; % 0.7 cm measured
b_width = b_width - 0.7;

b = (b_length ^ 3) * (b_width / (pi * b_length) - 0.142 * (1 - 10 ^
 (-1 * b_width / b_length)));
n = b / (4 * pi * (m_radius_long ^ 2) * (m_radius_short) / d_full);

fprintf('%d M&Ms can fit in the bag.\n\n', round(n));

fprintf('Iteration 7:\n');
fprintf('Assumptions:\n');
fprintf('     The shape of the bag is a "pillow" with a face that is
 7.62 cm by 9.525 cm.\n');
fprintf('     However, a quarter of a centimeter on each side of the
 aforementioned face is used to seal the bag and does not contribute
 to the volume.\n');
fprintf('     The shape of the M&M is an oblate spheroid with a short
 radius of 0.3 cm and a long radius of 0.6 cm.\n');
fprintf('     Void space exists in the bag.\n');
fprintf('     Mars Inc. packages the M&Ms in a planar hexoganal
 pattern to allow for easier bulk packaging and to prevent candy
 breakage.\n');

n = b / (4 * pi * (m_radius_long ^ 2) * (m_radius_short) / d);
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fprintf('%d M&Ms can fit in the bag.\n\n', round(n));

fprintf('Iteration 8:\n');
fprintf('Assumptions:\n');
fprintf('     The shape of the bag is a "pillow" with a face that is
 7.62 cm by 9.525 cm.\n');
fprintf('     However, a quarter of a centimeter on each side of the
 aforementioned face is used to seal the bag and does not contribute
 to the volume.\n');
fprintf('     The shape of the M&M is an oblate spheroid with a short
 radius of 0.3 cm and a long radius of 0.6 cm.\n');
fprintf('     Void space exists in the bag.\n');
fprintf('     Mars Inc. packages the M&Ms in a planar hexoganal
 pattern to allow for easier bulk packaging and to prevent candy
 breakage.\n');
fprintf('     Mars Inc. only fills its bags to 33%% (one-third) of its
 maximum capacity for flat packing to allow for easier packaging and
 to prevent candy breakage.\n');

b = b * 0.33; % estimation based on feasibility of the answer
n = b / (4 * pi * (m_radius_long ^ 2) * (m_radius_short) / d);

fprintf('%d M&Ms can fit in the bag.', round(n));
```

What is being requested?
Number of M&Ms in a fun-sized bag.
Identify parameters and variables. Give each a symbolic name.
Volume of bag: b
Volume of M&M: m
Number of M&Ms: n
Identify fundamental relationships between parameters.
b/m = n

Iteration 1:
Assumptions:
The shape of the bag is a cuboid with a face that is 8 cm by 8 cm.
The shape of the M&M is a sphere with a radius of 0.5 cm.
The height of the bag is equal to the diameter of one M&M.
There is no empty space in the bag.
122 M&Ms can fit in the bag.

Iteration 2:
Assumptions:
The shape of the bag is a cuboid with a face that is 8 cm by 8 cm.
The shape of the M&M is an oblate spheroid with a short radius of 0.3 cm and a long radius of 0.6 cm.
The height of the rectangular prism is equal to the shorter diameter of the M&M.
There is no empty space in the bag.
85 M&Ms can fit in the bag.

Iteration 3:
Assumptions:

The shape of the bag is a cuboid with a face that is 8 cm by 8 cm.

The shape of the M&M is an oblate spheroid with a short radius of 0.3 cm and a long radius of 0.6 cm.

The height of the rectangular prism is equal to the shorter diameter of the M&M.

Void space exists in the bag.

The M&Ms are packed in a hexogonal fasion in one flat layer (hexoganal planar packing pattern).

26 M&Ms can fit in the bag.

Iteration 4:
Assumptions:

The shape of the bag is a rectangular prism with a face that is 7.62 cm by 9.525 cm.

The shape of the M&M is an oblate spheroid with a short radius of 0.3 cm and a long radius of 0.6 cm.

The height of the rectangular prism is equal to the shorter diameter of the M&M.

Void space exists in the bag.

The M&Ms are packed in a hexogonal fasion in one flat layer (hexoganal planar packing pattern).

29 M&Ms can fit in the bag.

Iteration 5:
Assumptions:

The shape of the bag is a "pillow" with a face that is 7.62 cm by 9.525 cm.

The shape of the M&M is an oblate spheroid with a short radius of 0.3 cm and a long radius of 0.6 cm.

Void space exists in the bag.

The M&Ms are packed in a 3-D hexogonal fasion.

104 M&Ms can fit in the bag.

Iteration 6:
Assumptions:

The shape of the bag is a "pillow" with a face that is 7.62 cm by 9.525 cm.

However, 0.7 centimeters on each side of the aforementioned face is used to seal the bag and does not contribute to the volume.

The shape of the M&M is an oblate spheroid with a short radius of 0.3 cm and a long radius of 0.6 cm.

The height of the rectangular prism is equal to the shorter diameter of the M&M.

Void space exists in the bag.

The M&Ms are packed in a 3-D hexogonal fasion.

80 M&Ms can fit in the bag.

Iteration 7:
Assumptions:

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     The shape of the bag is a "pillow" with a face that is 7.62 cm by
 9.525 cm.
     However, a quarter of a centimeter on each side of the
 aforementioned face is used to seal the bag and does not contribute
 to the volume.
     The shape of the M&M is an oblate spheroid with a short radius of
 0.3 cm and a long radius of 0.6 cm.
     Void space exists in the bag.
     Mars Inc. packages the M&Ms in a planar hexoganal pattern to
 allow for easier bulk packaging and to prevent candy breakage.
60 M&Ms can fit in the bag.

Iteration 8:
Assumptions:
     The shape of the bag is a "pillow" with a face that is 7.62 cm by
 9.525 cm.
     However, a quarter of a centimeter on each side of the
 aforementioned face is used to seal the bag and does not contribute
 to the volume.
     The shape of the M&M is an oblate spheroid with a short radius of
 0.3 cm and a long radius of 0.6 cm.
     Void space exists in the bag.
     Mars Inc. packages the M&Ms in a planar hexoganal pattern to
 allow for easier bulk packaging and to prevent candy breakage.
     Mars Inc. only fills its bags to 33% (one-third) of its maximum
 capacity for flat packing to allow for easier packaging and to
 prevent candy breakage.
20 M&Ms can fit in the bag.
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