

ENGR 101 - Winter 2004

Project 1: To the Stars

Due: Friday, 16-January-2004 5:00 p.m.
Grading: 50 points



1.0 Background Info

Escape velocity is the speed that an object needs to be traveling to break free of a planet or moon's gravity well. For example, a spacecraft leaving the surface of Earth needs to be going 7 miles per second, or nearly 25,000 miles per hour to escape Earth.



A Delta II rocket blasting off. A large amount of energy is needed to achieve escape velocity. Photo from Jet Propulsion Laboratory's Planetary Missions & Instruments Image Gallery <http://www-b.jpl.nasa.gov/pictures/browse/pmi.html>

Since escape velocity depends on the mass of the planet or moon that a spacecraft is blasting off of, a spacecraft leaving the moon's surface could go slower than one blasting off of the Earth, because the moon has less gravity than the Earth. On the other hand, the escape velocity for Jupiter would be many times that of Earth's because Jupiter is so huge and has so much gravity.

The minimum velocity V_{esc} with which a space ship to the moon must be launched from the earth to escape the earth's gravitational field is called the escape velocity and can be calculated by

$$v_{esc} = \sqrt{\frac{2GM}{R}}$$

where G is the gravitational constant, M and R are the mass and radius of the object you are trying to "escape". G (always written in uppercase) converts the mass and distance to an amount of gravitational acceleration. The result is in meters-kilograms-second (mks) units.

$$G = 6.670 \times 10^{-11} \frac{m^3}{kg \cdot sec^2}$$

1.1 Problem Statement

Write a program that calculates the escape velocity needed for a spacecraft to escape from the Earth. Note that the escape velocity does not depend on the mass of the spacecraft; hence, this speed is the required velocity that must be attained for any object to escape from the Earth: space-ships, cannonballs, volcanic ejecta, dust particles, anything!!!

Then calculate the escape velocity for the Moon. (This should explain why the Apollo astronauts needed only a small vehicle to leave the Moon's surface and return to lunar orbit, while the Saturn-V rocket used to lift everything off of the face of the Earth was so huge!)

How fast would your spacecraft have to travel to escape from Mars? Hum, what would the velocity need to be is SPIRIT wanted to come home???

How fast would you need to travel to escape from Jupiter?

FYI: Individual atoms and molecules of gas in a planet's atmosphere also have to reach these same escape velocities in order to "leak off" into space; otherwise, they stay trapped close to the planet's surface, just like us. Hum, I wonder if this has anything to do with why the Moon has virtually no atmosphere, Earth has a moderate amount, and Jupiter's is HUGE.

Data for Objects		
Name of Object	Mass	Radius
Earth	5.976E24 kg	6378 km
Moon	7.35E22 kg	1738 km
Mars	6.574E23 kg	3397 km
Jupiter	1.9E27 kg	71492 km

1.2 Input Requirements

The input to the program, via standard input `cin`, consists of the name of the object wishing to escape from, the mass of the object, and the radius of the object in that order and separated by whitespace. See the sample run below.

1.3 Output Requirements

The output must include the escape velocity required. Your output should be in km/sec and in miles/sec. See the sample run below. A handy conversion is: 1 km = .6214 miles.

1.4 Sample Run

Test run #1:

```
Enter the name of the object, its mass, and its radius:
:> Earth 5.976E24 6378
```

```
Escape velocity for Earth is:
 11.18 km/sec      Or
 6.94724 miles/sec
```

Thanks for flying with SPIRIT

Test run #2

```
Enter the name of the object, its mass, and its radius
:> Moon 7.35E25 1738
```

```
Escape velocity for Moon is:
 75.1098 km/sec    Or
 46.6732 miles/sec
```

Thanks for flying with SPIRIT

Note: this example has the wrong mass for the moon, so the escape velocity, while computed correctly, is wrong.

1.5 Submission Requirements

The code should be in a file named `escape.cpp` placed in your `hw1` directory by 5:00 p.m. on the due date.

Tools for checking your code

In the directory `/afs/engin.umich.edu/class/w04/eng101/hagar/Tools` you will find a version of this program named `escapeReference`. These will execute on PC class machines running Linux. You can use these to help verify that your code produces correct results.

You can run automated tests on your code by running the auto tester that you will also find in `/afs/engin.umich.edu/class/w04/eng101/hagar/Tools`. Run this as `eng101test hw1`. This test routine will invoke the same system that we will use to automatically grade your code.

