

# PHYS 2411 Homework 1

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## Problem 1

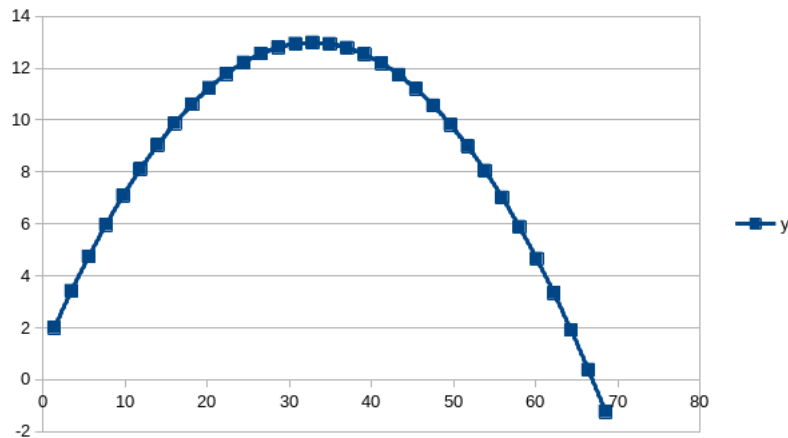
The analytical formula for the Doppler effect is  $f_o = f_s(1 + v_{rel}/c) \Leftrightarrow v_{rel} = c(f_o/f_s - 1)$ . Evaluating this at the values given in the problem yields  $v_{rel} = (3 \times 10^8) \left( \frac{103.3 \times 10^6 + 9.44}{103.3 \times 10^6} - 1 \right) = 27.415295256$ . The program in the attached script file computes this in two ways. The first algorithm results in  $v_{rel} = 20.788805008$  while the second results in  $v_{rel} = 27.4152946472168$ . Comparing this to the analytic solution found via the above method, the second clearly has much higher precision, since it agrees with the analytic solution to 5 digits.

## Problem 2

Refactoring the above program to use double instead of single precision, we get agreement to 13 digits of both algorithms with the analytical solution.

## Problem 3

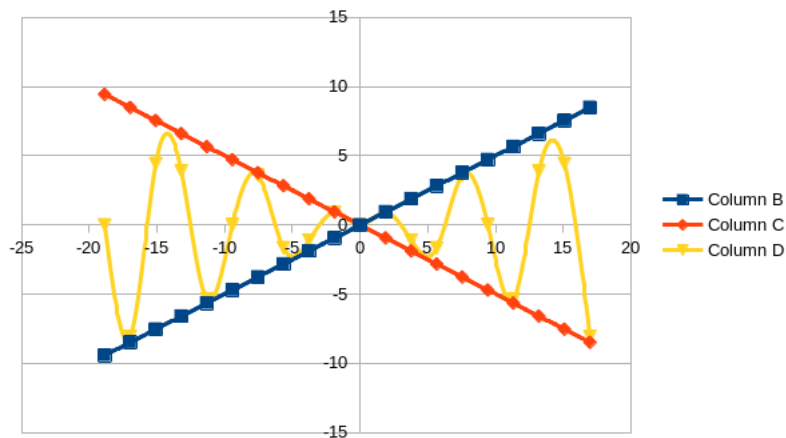
The plot of the output data appears below.



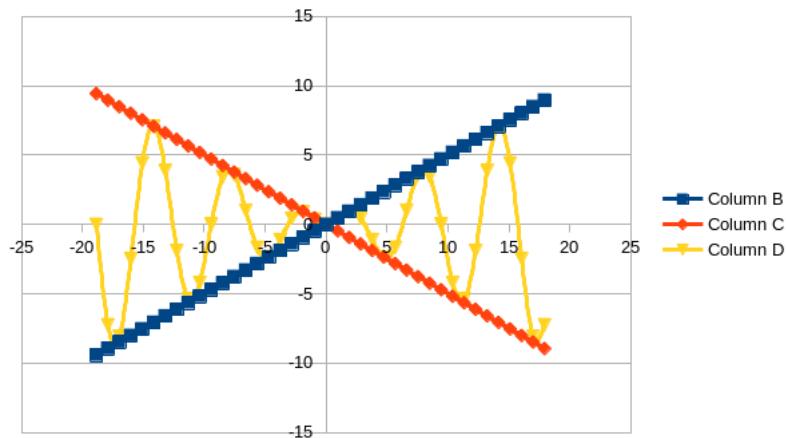
From the output data, the ball appears to hit the ground after about 3.1 seconds.

## Problem 4

The plot for  $m = 20$  is



For  $m = 40$ , we have



Evidently, the greater resolution makes the plots more accurate. In the first plot, the curve misses the bounding line by a noticeable margin at its highest point, whereas in the second it touches it. It is, of course, expected that it will touch the bounding line.

## Script Files

### 0.1

Script started on Fri 10 Sep 2021 03:46:59 PM CDT  
tput: unknown terminal "st-256color"

```

tcsh: No entry for terminal type "st-256color"
tcsh: using dumb terminal settings.
[dwilk14@tigers ~/HW1]$ cat p1.cpp
#include <iostream>
#include <iomanip>
using namespace std;

int main (){
    const float c=3.e8; // speed of light, m/s
    float fs,fo,deltaf,vrel; // fs, source frequency, Hz
    // fo, frequency detected by object, Hz
    // deltaf, frequency shift, Hz
    // vrel, object velocity, m/s
    fs=103.3e6;
    deltaf=9.44;

    cout << "Algorithm (i):" << endl;
    fo=fs+deltaf;
    vrel=fo*c-fs*c;
    vrel=vrel/fs;
    cout << "v=" << setprecision (15) << vrel << " m/s" << endl;

    cout << "Algorithm (ii):" << endl;
    vrel=deltaf*c/fs;
    cout << "v=" << setprecision (15) << vrel << " m/s" << endl;

    cout << "Just a check:" << endl;
    cout << "v=" << setprecision (15)
        << 9.44*(3.e8)/((double) fs) << " m/s" << endl;

    return 0;
}
[dwilk14@tigers ~/HW1]$ g++ p1.cpp -o p1
[dwilk14@tigers ~/HW1]$ ./p1
Algorithm (i):
v=20.7888050079346 m/s
Algorithm (ii):
v=27.4152946472168 m/s
Just a check:
v=27.4152952565344 m/s
[dwilk14@tigers ~/HW1]$ cp dwilk14_hw1p1.txt /home3/kristina/phys2411/.
[dwilk14@tigers ~/HW1]$ exit
exit

```

Script done on Fri 10 Sep 2021 03:47:46 PM CDT

## 0.2

```
Script started on Fri 10 Sep 2021 03:47:54 PM CDT
tput: unknown terminal "st-256color"
tcsh: No entry for terminal type "st-256color"
tcsh: using dumb terminal settings.
[dwilk14@tigers ~/HW1]$ cat p2.cpp
#include <iostream>
#include <iomanip>
using namespace std;

int main (){
    const float c=3.e8; // speed of light, m/s
    double fs,fo,deltaf,vrel; // fs, source frequency, Hz
    // fo, frequency detected by object, Hz
    // deltaf, frequency shift, Hz
    // vrel, object velocity, m/s
    fs=103.3e6;
    deltaf=9.44;

    cout << "Algorithm (i):" << endl;
    fo=fs+deltaf;
    vrel=fo*c-fs*c;
    vrel=vrel/fs;
    cout << "v=" << setprecision (15) << vrel << " m/s" << endl;

    cout << "Algorithm (ii):" << endl;
    vrel=deltaf*c/fs;
    cout << "v=" << setprecision (15) << vrel << " m/s" << endl;

    cout << "Just a check:" << endl;
    cout << "v=" << setprecision (15)
        << 9.44*(3.e8)/((double) fs) << " m/s" << endl;

    return 0;
}
[dwilk14@tigers ~/HW1]$ g++ p2.cpp -o p2
[dwilk14@tigers ~/HW1]$ ./p2
Algorithm (i):
v=27.4152952565344 m/s
Algorithm (ii):
v=27.4152952565344 m/s
Just a check:
v=27.4152952565344 m/s
[dwilk14@tigers ~/HW1]$ cp dwilk14_hw1p2.txt /home3/kristina/phys2411/.
[dwilk14@tigers ~/HW1]$ exit
exit
```

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### 0.3

Script started on Fri 10 Sep 2021 03:48:36 PM CDT

tput: unknown terminal "st-256color"

tcsh: No entry for terminal type "st-256color"

tcsh: using dumb terminal settings.

[dwilk14@tigers ~/HW1]\$ cat p3.cpp

```
#define _USE_MATH_DEFINES
```

```
#include <fstream>
```

```
#include <cmath>
```

```
#include <iostream>
```

```
using namespace std;
```

```
int main() {
```

```
    float x0 = 1.4;
```

```
    float y0 = 2.0;
```

```
    float v0 = 25.6;
```

```
    float theta = 35.0 * M_PI / 180.0;
```

```
    float g = 9.81;
```

```
    float x = x0;
```

```
    float y = y0;
```

```
    ofstream outfile("p3_out.txt");
```

```
    outfile << "t      x      y" << endl;
```

```
    float t = 0.0;
```

```
    while (y > 0.0) {
```

```
        x = x0 + v0 * cos(theta) * t;
```

```
        y = y0 + v0 * sin(theta) * t - g * pow(t, 2) / 2;
```

```
        outfile << t << "\t" << x << "\t" << y << endl;
```

```
        t += 0.1;
```

```
    }
```

```
    return 0;
```

```
}
```

[dwilk14@tigers ~/HW1]\$ g++ p3.cpp -o p3

[dwilk14@tigers ~/HW1]\$ ./p3

[dwilk14@tigers ~/HW1]\$ cp dwilk14\_hw1p3.txt /home3/kristina/phys2411/.

[dwilk14@tigers ~/HW1]\$ exit

exit

Script done on Fri 10 Sep 2021 03:49:16 PM CDT

## 0.4

Script started on Fri 10 Sep 2021 03:49:23 PM CDT

tput: unknown terminal "st-256color"

tcsh: No entry for terminal type "st-256color"

tcsh: using dumb terminal settings.

[dwilk14@tigers ~/HW1]\$ cat p4.cpp

```
#include <fstream>
```

```
#include <iostream>
```

```
#include <cmath>
```

```
using namespace std;
```

```
int main() {
```

```
    ofstream outfile("p4_out.txt");
```

```
    double pi = 3.141592653589793;
```

```
    int m1 = 20;
```

```
    int m2 = 40;
```

```
    double step1 = 12 * pi / m1;
```

```
    double step2 = 12 * pi / m2;
```

```
    outfile << "m = 20:" << endl;
```

```
    outfile << "x" << "\t" << "x/2" << "\t" << "-x/2" << "\t" << "0.5xsin(x)" << endl;
```

```
    for (int i = 0; i < m1; i++) {
```

```
        double x = -6 * pi + step1 * i;
```

```
        outfile << x << "\t" << x/2 << "\t" << -1 * x/2 << "\t" << 0.5 * x * sin(x) << endl;
```

```
    }
```

```
    outfile << endl << "m = 40:" << endl;
```

```
    outfile << "x" << "\t" << "x/2" << "\t" << "-x/2" << "\t" << "0.5xsin(x)" << endl;
```

```
    for (int i = 0; i < m2; i++) {
```

```
        double x = -6 * pi + step2 * i;
```

```
        outfile << x << "\t" << x/2 << "\t" << -1 * x/2 << "\t" << 0.5 * x * sin(x) << endl;
```

```
    }
```

```
    return 0;
```

```
}
```

```
[dwilk14@tigers ~/HW1]$ g++ p4.cpp -o p4
```

```
[dwilk14@tigers ~/HW1]$ ./p4
```

```
[dwilk14@tigers ~/HW1]$ cp dwilk14_hw1p4.txt /home3/kristina/phys2411/.
```

```
[dwilk14@tigers ~/HW1]$ exit  
exit
```

Script done on Fri 10 Sep 2021 03:50:21 PM CDT