2nd MRSI – Multiple Rounds Simultaneous Impact

Background: http://www.youtube.com/watch?v=WghCzSKySxA

By varying propellant in artillery shells multiple trajectories can be created for any target. Computer generated firing plans can allow a single Howitzer to fire multiple shells sequentially that will land virtually simultaneously on a single target.
In the last project we created a multiple firing plan for 8 shells at a target up to 40km away fired 12 seconds apart. The military has been unable to devise a method of altering the shell propellant dynamically and has requested a new program to address this issue. You are to create a program to assist in the new MRSI program. Under the new program shell velocities are fixed and firing times are to be altered.

Create a program to assist MRSI calculations. Shells come in 6 fixed velocities.

Type A has max velocity of a shell is 1660m/s.
Type B has max velocity of a shell is 1550m/s.
Type C has max velocity of a shell is 1440m/s.
Type D has max velocity of a shell is 1330m/s.
Type E has max velocity of a shell is 1220m/s.
Type F has max velocity of a shell is 1110m/s.

Given a firing range of up to 40km, generate a MRSI firing plan for up to 12 shells.

The gun requires a minimum of 6 seconds for reloading between the first 4 rounds.
The gun requires 12 seconds between rounds for successive rounds after 4 to prevent overheating.

The firing plan consists of the following components: firing time, shell type, and angle. You will also provide the horizontal and vertical velocity vectors. For purposes of calculation assume the gravitational constant, g, is 9.8 m/s2 and that wind resistance is negligible.

The input to your program will consist of

Range in kilometers (km): __
Time of impact (hh:mm): __

The program output will be a 5 column table up to 12 lines long.

Time hh:mm:ss	Shell Type	Angle (deg)	VX (m/s)	VY (m/s)
__:__:__	_	__._	___.__	__.__
__:__:__	_	__._	___.__	__.__
__:__:__	_	__._	___.__	__.__
__:__:__	_	__._	___.__	__.__
__:__:__	_	__._	___.__	__.__
__:__:__	_	__._	___.__	__.__
__:__:__	_	__._	___.__	__.__
__:__:__	_	__._	___.__	__.__
__:__:__	_	__._	___.__	__.__

Formulas of interest: (Vy is vertical and Vx is horizontal velocity.)

AirTime = 2 (Vy / g)
CruiseTime = TargetRange / Vx
AirTime = CruiseTime
ShellVelocity**2 == Vx**2 + Vy**2

Notes:

Shell Type A produces longest and shortest shells.
Shell Type F produces the two middle shots above and below 45 degrees.

Algorithm Hints:

We have a system of equations with two unknowns (Vx and Vy).
Replace Vy with an expression using Vx then solve for Vx.
Solve for Vx by solving quadratic equations.
Using Vx solve for Vy.

Quadratic equations have this form:

ax2+bx+c = 0

Where a, b, and c are constants, x can be solved using quadratic roots:

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

The part under the square root symbol is called the determinant.

$$\Delta = b^2 - 4ac.$$

The determinant may have 0, 1, or two roots. For our application it will have two, one positive and one negative root. Each root produces a firing solution. Hence there are up to 12 solutions given 6 shell velocities.

Execution Example:

```
Enter range to target (km):40
You entered 40.000
Enter time of target detonation(HH:MM):12:30
You entered 12:30
Time     Shell Angle       VX       VY
hh:mm:ss Type  (deg)    (m/s)    (m/s)
12:24:22 A      85.9   118.37  1655.77
12:24:45 B      85.3   126.88  1544.80
12:25:07 C      84.6   136.73  1433.49
12:25:30 D      83.6   148.29  1321.71
12:25:53 E      82.4   162.09  1209.18
12:26:16 F      80.7   178.92  1095.49
12:29:23 F       9.3  1095.49   178.92
12:29:36 A       4.1  1655.77   118.37
Press any key to continue . . .
```