COMP 2406 Fall 2023 Term Project Assignment (Assign 5)

OPTION A: Based on Web Sockets Portion of the Course (Tutorial 5, Assg 3)

Due: Fri. Dec. 8 by 10:00pm (submitted to brightspace)

All assignments must be submitted using brightspace by the due data and time. No other assignments will be accepted or marked.

Project Web Application

COMP 2406 fall 2023 has a project assignment worth 10% of the course grade. Some of the parts might have been worked on in the previous exercises and you can reuse any useful content from the course.There are two options provided for the term projects: one based on Real-Time collaboration (Tutorial 05) the other on the later database portion of the course.

This assignment is OPTION A -based on Web Socket material covered earlier in the course (tutorial 5 and Assignment 3).

For this project you are required to turn the single-client Curling demonstration game into a multi-player online game in which clients are synchronized through web sockets. The demonstration starting code is in the course notes section "13 Real-Time Collaboration with Web Sockets" and the single-client Curling demonstration code in the notes section: "10 Classes and Containers"

Node.js/Javascript Real-Time Collaborative App

In this project you will build a real-time collaborative app based on web sockets. Since this is meant to be an app that allows people working in different browsers to collaborate you can take advantage of the fact that we can host servers on the OpenStack virtual machines that can be reached by several different machines. If you run your server on an openstack machine with a floating IP address allocated others will be able to reach it from their own machines.

In this project you can build a single page client-server app based primarily on native capabilties of Node.js, however you will use the npm module **socket.io** to implement asynchronous real-time data exchange between client and server. You are also free to import (or more correctly "require") other simple npm modules from the npm (node package manager) registry. You will likely not need the use of Express.js and similar "high level" frameworks but you can certainly use them if you want. helper modules.

Marking: This assignment is based on 16 design requirements numbered **R1.1**...**R3.11** for a total of 32 marks.

Marks are awarded, or deducted, based on requirements as follows:

Req Type	Assignment Grading
R0.x	**Critical Submission and Intent Requirements.** Assignment (or problem in some cases) gets 0 if **any** critical submission requirement (shown in red) is not met. CRITICAL SUBMISSION FOR TERM ASSIGNMENTS APPLY -REVIEW THOSE IF NECESSARY
R0.x	**Good Practice Requirements.** You lose 2 marks for any good practice requirement (shown in amber) not met. GOOD PRACTICE REQUIREMENTS FROM PREVIOUS TERM ASSIGNMENTS APPLY -REVIEW THOSE IF NECESSARY.
Rx.x	**Design Requirements.** You earn 2 marks for each design requirement (green) satisfied, well implemented, and demonstrated as requested; 1 mark if it's partly met, met but not well implemented, or met but not demonstrated; and 0 if it's not attempted or met.

Submission (what to submit):

Question	Devliverable to Submit
Part 1	Your entire code project for client and server side code and any related media or data files.
Part 2	a link to your YouTube video with sound demonstrating your database. Provide the link in the readme.txt included with your submission.

YouTube Demonstration Of Your Application

Provide a link to a YouTube video of your application with you giving us a demonstration and walkthrough of you app.

Intent Requirement R0.2 You must provide, in your ReadMe.txt file, a link to a YouTube demonstation video that we can actually watch (that is "unlisted"). If we cannot watch your video because the link is not valid or the video is "private" then no marks will be awarded for the assignment.

0 marks for the assignment if there is no viewable YouTube video link.

Video Length Requirement R0.3 Your YouTube demonstation video must not be more than 10 minutes long. I will only require the TA's to watch the first 10 minutes. If your video is actually longer make sure to demonstrate the essential requirements and use cases within the first 10 minutes.

Application Requirements

Background

For this assignment you will build a online multi-player game that features real-time collaboration between, or among, more than one browser client at the same time -ideally running on different machines. You will build a multi-player interpretation of a curling game based on an existing single-client demo version provided in the course notes.

Real-time collaboration using web sockets is illustrated in tutorial 05 and you should work on tutorial 05 before you start coding this assignment -though you can think about the design beforehand. You can use that code if you want or abandon it completely -this assigment can be started from a "clean slate". The main design challenges will be to decide what gets communicated between client and server and who decides things like where the curling stones are, how they move, where and when collisions take place, and how stones deflect as a result of the collisions.

For this application two users with separate browsers are players but other browsers can be spectators viewing the game being played. So there will generally be more than two browsers involved. The two players would each have control of one colour of curling stone (the home team and the visitor team). A player will shoot the stone with their mouse as described in the requirements below and the motion and collisions of the stones will appear synchronized in all the clients.

Demo Code: We have provided a single-client simulation of the curling game. It is posted in the notes section "10 Classes and Containers". Your goal will be to turn this into a multi-player online game. You will have to make all the design decisions about what data is stored on the server and how data is exchanged with the clients. You are free to use as much of the demo code as you want or abandon it alltogether.

To play the demo application you need to first register as both the home and visitor player by pressing the provided buttons. After which you you can shoot from the shooting area for those players. The colour of the box around the score shows whether you are registered. The colour of the shooting area box shows which player should shoot next. Here is our YouTube demonstration of the provided code which was presented as a video lecture.

1) Server-Side Requirements

R1.1 The server code be programmed in javascript or typescript.

R1.2 The real-time collaboration between client and server should be based on web sockets and in particular use the npm **socket.io** module or other web socket module.

R1.3 The server-side javascript should keep track of, or manage, who has permission to control (or shoot) a stone and not allow players to shoot out of turn or allow spectators to shoot the stones. Other browers should only be allowed to spectate and see the game happening in real-time. Note this app can be done entirely in the main memory of the server. This assignment does not require that you read and write any files (except the static files that deliver the app's webpage) or use a database.

R1.4 Server should be hosted on port 3000. The initial launch of the web app should be the result of the client making a request to `http://localhost:3000/curling.html`.

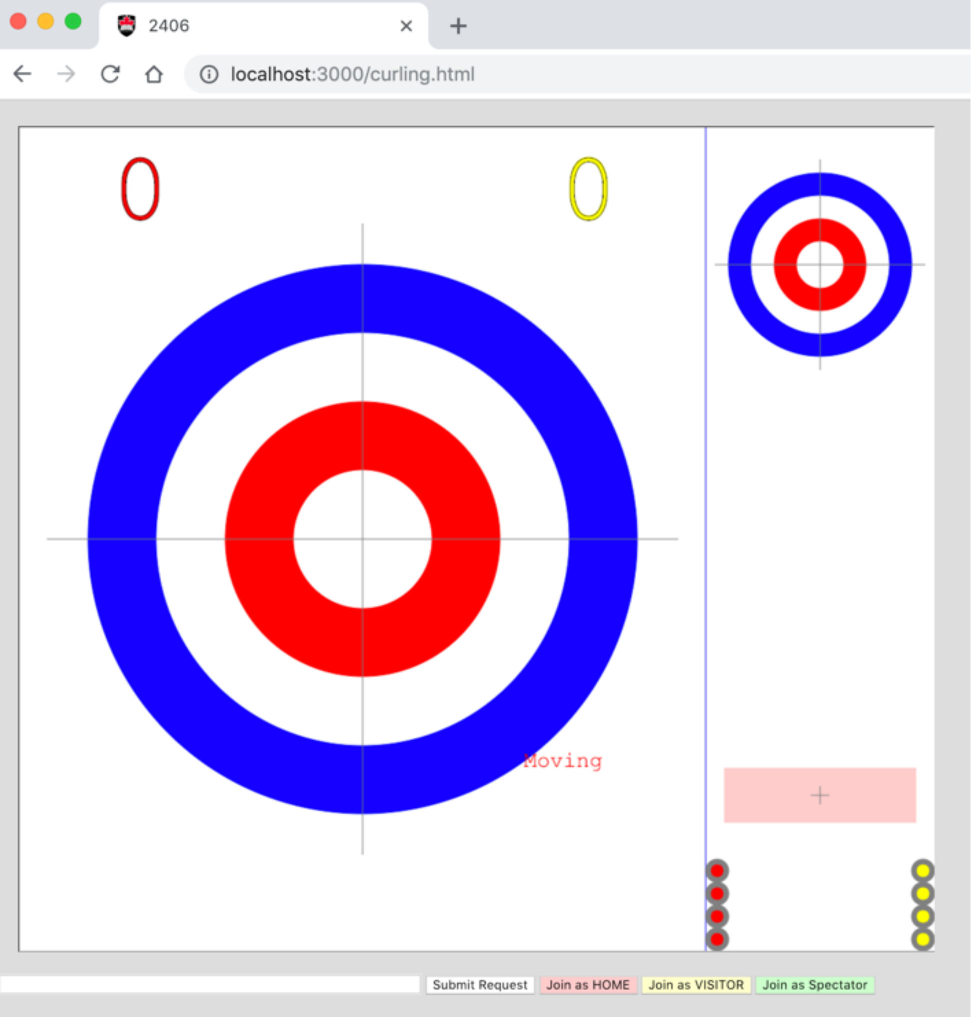
If on the otherhand you are hosting your server on one of our openstack machines then you will access it using an actual IP address instead of localhost using a URL like the following:
`http://134.117.217.107:3000/curling.html`

2) Client-Server Data Exchange

R2.1 The data exchanged during the game between clients and server should be in the form of JSON object strings. The initial launch of the client web page will just be the result of a GET request for a static application .html file and other supporting files after that it should be JSON data exchange. In other words this is a single-page app from any client's perspective.

3) Client Requirements

R3.1 Launch: When the app first launches the client should see the game layout of the app. It should look something like the following (based on the demo code) but you can make minor changes if you want. The changes you make, however, should still allow someone familiar with the demo code to "drive" your app. [You should remove the text-field, submit button, and moving word from the demo code though.]

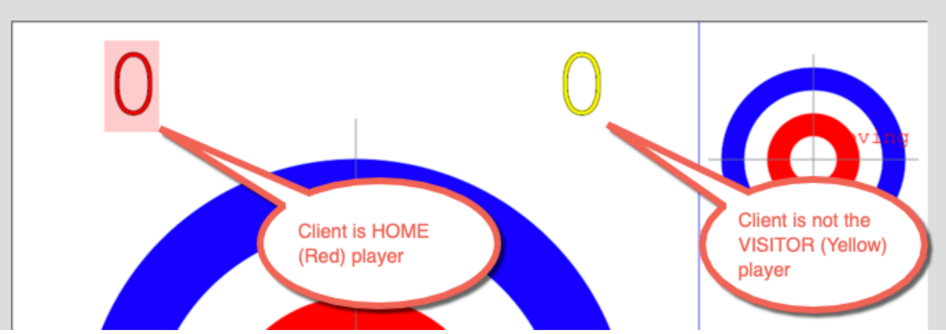


R3.2 Player registration: When the game launches the appearance of the **Join as HOME**, **Join as VISITOR**, and **Join as Spectator**, buttons should indicate whether those are available to the client. If another client is already registed as the HOME player, for example, then the **Join as HOME** button should be disabled. When a player joins the game the status of the buttons should change accordingly on all clients who have joined as players or spectators.

There are no synchornization requirements on clients who have not joined. In other words, synchronization is only required once a client actually joins as either a player or a spectator.

R3.3 Player registration: Only one client should be allowed to join as the HOME player and one as the VISITOR player. But, to allow easy testing for example, a single client should be allowed to join as both the HOME and VISITOR player. Once a client has joined as a player the scoreboard part of the application should indicate that that client is a player. In the demo code, for example, a coloured box around the score indicates the client is the player. [Rev 2: Spectators should be able to join a game already in progress.]

[Optionally, if you want, you can have the joining players supply their name or userid and display that on all the clients as well. You could use the text-field cointained in the demo code for that if you choose to implement this.]


0
0
ving
Client is HOME (Red) player
Client is not the VISITOR (Yellow) player

R3.4 Shooting: A client should not be able to shoot, or move, the stones unless they are the registered (joined) player. Clients who join as a spectator should not be allowed to shoot or control the game in any way.

R3.5 Shooting: A player client should not be allowed to shoot out of turn. Moreover the application should indicate whose turn it is to shoot next. Like in the demo code, a coloured box should be drawn in the shooting area to indicate who should shoot next. Also, like the demo code, shooting should be disabled while stones are in motion and not allow the next player to shoot until the stones come to rest. The "next turn" coloured box should appear on all clients who have joined either as players or spectators.

R3.6 Shooting: Players should shoot the stones "catapult style" as is done in the demo code. Players shoot from the designated shooting area indicated by the coloured box. When the mouse is pressed in the shooting area by the player whose turn it is to shoot their stone should get positioned at the mouse press location [already done in the demo code]. Shooting should appear synchronized in all registered clients and the spectators should be able to see the aiming of the shooting catapult.

R3.7 Synchronized motion: The app should show any motion and collisions of the stones on all registered browser clients and the views should be synchronized. The motion should look the same on all the browsers watching. [Rev 2: spectators should be able to join games already in progress.]

R3.8 Close Up View: When the stones get close to the curling circles they should show up in the close up view on all the browsers watching. This should appear synchronized on all registered clients.

R3.9 Collisions: The stones should move and collide with each other in a realistic, or at least pleasing, way. The motion and collisions should appear synchronized in all the browsers watching. You will have to decide where collision decisions are made (server, one browser, two browsers, browsers taking turns, etc.) and what motion data is sent between clients and server. You should be mindful of what data is being passed back and forth. If you intend to pass your whole representation of the world around whenever anything happens that will generate a lot of network traffic. On the other hand, passing around only what is needed might smooth things out a lot. This is obvioulsy a critical design decision in designing real-time collaboration apps.

At the end of this assignment is an explanation of how the collision math in the demo code was programmed.

R3.10 Hammer Time: In the demo code the colour that shoots first just alternates after each end (round). But in curling the team that earns a point in the previous round shoots first in the next round. This gives the team that did not score in the previous round **the hamme**r, or the last shot. Your application should do this by ensuring the team (home or visitor) that scores and end must shoot first in the next end.

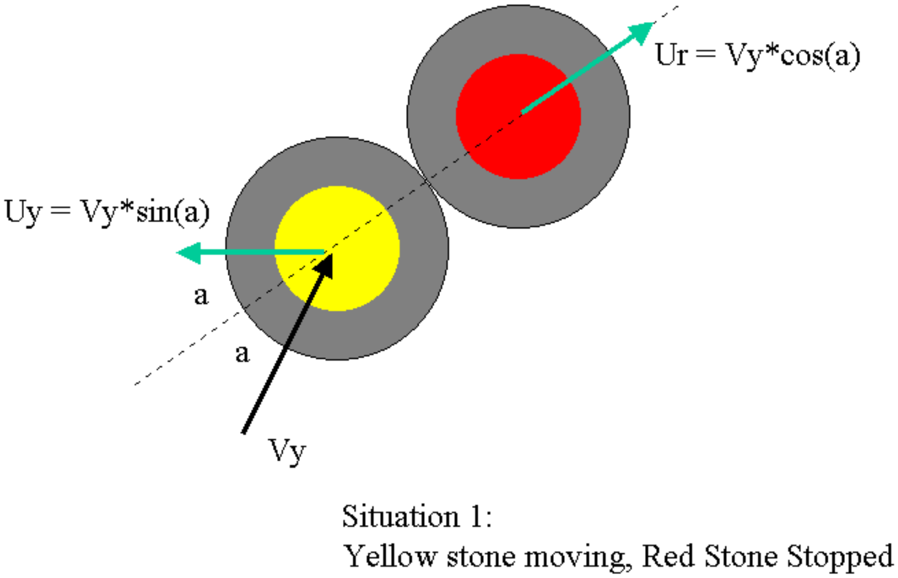
R3.11 Deregistration: A client should be able to deregister, or un-join, the game by either closing their browser, or browser tab, or by reloading the page. The effect of one of these actions should be to send a socket message to the server that will de-register the client. When this happens the status should be reflected in all the other registered clients. For example, if the HOME player leaves then the **Join as HOME** button on all the other clients should become enabled allowing one of them to join as a player.

Help with Collision Math

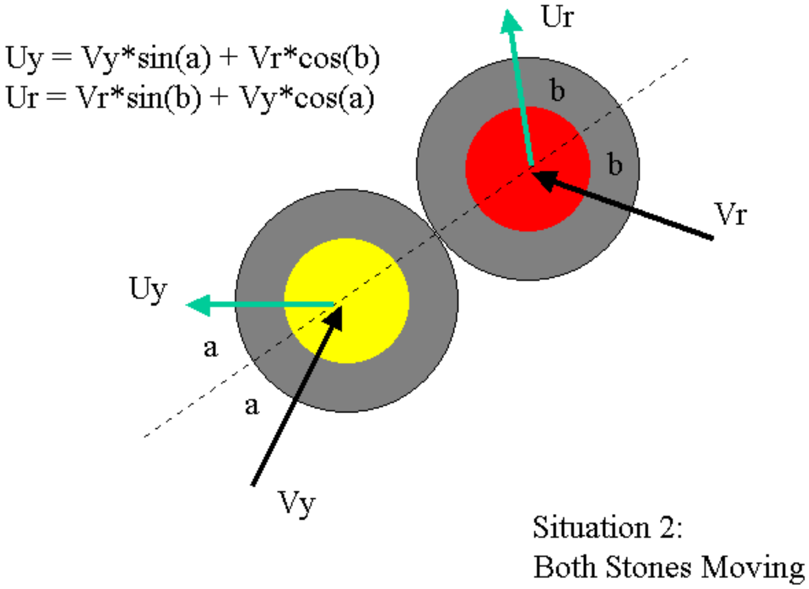
Here is an explanation of how the collision math in the demo code was programmed. It is already done -you don't have to implement this but the explanation might be helpful in understanding the demo code. It is based on high-school geomery only and not physics. It is not physics because there are no forces, mass, or acceleration in the model. (If there is no force then there is no physics.)

Mathematics of Collisions

Below are two balls, weights, or curling stones (of equal mass), hitting each other.



In the simple situation above the red weight is stationary and the yellow weight hits it. When two weights collide, the line through their centers is called the "line of impact". (Two weights collide when their centers are two weight radius lengths from each other). Suppose the yellow weight is traveling with velocity Vy at an angle "a" with the line of impact. After collision, the red weight will travel along the line of impact with a velocity approximately Ur = Vy*cos(a). The yellow weight will travel away with the same angle "a" but on the opposite side of the line of impact, with a velocity of approximately Vy*sin(a). In the next situation both weights are moving.



If both weights are moving the situation is similar but each imparts some velocity to the other. For example suppose the yellow weight is traveling with velocity Vy at an angle "a" with the impact line and the red weight is traveling with velocity Vr at an angle of "b" with the impact line. The yellow weight will bounce off again at an angle "a" with the impact line, but with approximate velocity Uy = Vy*sin(a) + Vr*cos(b). The red weight will bounce off at angle "b" with approximate velocity Ur = Vr*sin(b) + Vy*cos(a).

When programming simulations like this the velocity of the weights or balls is typically stored in a vertical and horizontal component. That is, the vertical direction velocity is stored separately from the velocity in the horizontal direction. This makes it easy do to the animation, and is explained further below.

The demo code is based on this analysis and works as follows: For each animation timer event, see which weights are moving and move them. Next see if any weights have collided. If so, adjust their velocities accordingly. In the demo code the stones maintain a boolean to indicate whether they are in motion or not -just to make checking easier.

Simulations like this typically have to be debounced and the tunneling problem has to be accounted for. **Debouncing** refers to making sure the same event is not processed, and reacted to, more than once. **Tunneling** refers to be fact that when stones collide they will actually be overlapping. If they bounce off each other but don't clear the overlap before the next animation timer event they will still be overlapping (i.e. will have tunnelled into each other). These problems are handled in the demo code by making collisions objects (instances of class `Collision`) and placing collisions in a collision set (instance of `CollisionSet`) which prevents a collision from being processed more than once.

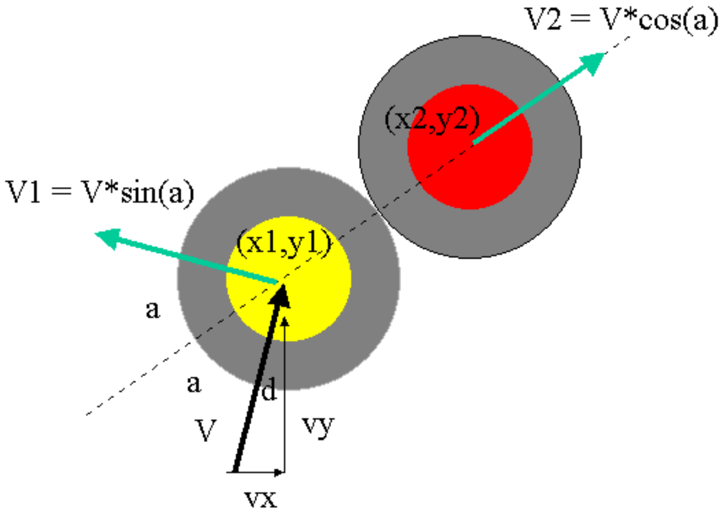
Hints with the Math

Here is a further explanation of the math for collisions when the horizontal and vertical components of the velocity are stored separately. This is how the collisions are modelled in the demo code.

Lets examine the simple situation where weight 1 is moving and hits a stationary weight 2.

At the point of collision what do we know? We know the positions of each weight, (x1,y1) and (x2,y2). We know horizontal and vertical velocity of each weight, v1x, v1y, v2x = 0, v2y = 0. We know the weight's centers are 2R apart (R is the radius of a weight).
The velocity vector of weight1, called V, has magnitude sqrt(v1x*v1x + v1y*v1y); Weight2 is stopped so its velocity is 0.

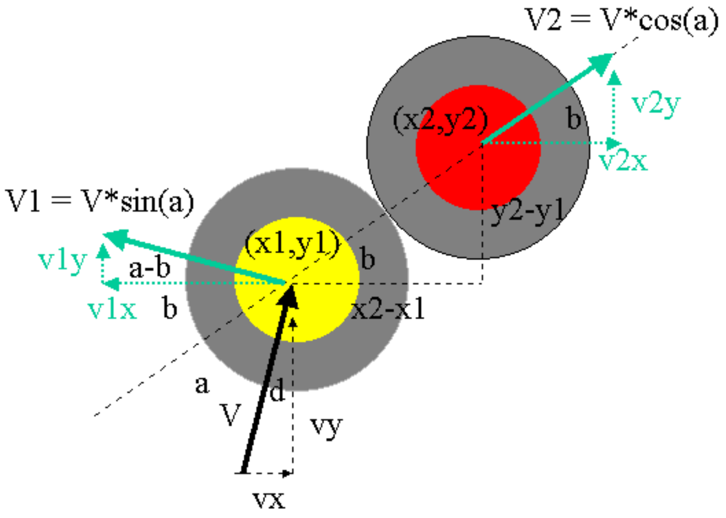
Our objective is to figure out the new vx and vy for the two weights after the collision. Looking at the situation 1 picture above we know the moving weight will depart at the same angle to the line of impact as it arrived -but on the opposite side, and we know the struck weight will depart along the line of impact. So everything we know at the point of collision is shown on the picture below.



Situation 1:
Yellow stone moving, Red Stone Stopped

First off, realize that the the model we are using is a very simple (first order) approximation. That is, you will notice V1 = V*sin(a) and V2 = V*cos(a). This is not strictly accurate. It is based on the approximation that sin(a) + cos(a) ~= 1. The approximation has it maximum error at a=45 degrees. A better approximation would be use the more correct formula $\sin^2(a) + \cos^2(a) = 1$. If you want to use the more accurate interpretation for your code that is fine. In that case the speeds should be $V1=V*\sin^2(a)$; $V2=V*\cos^2(a)$. I will continue though with the simpler model as it would probably suffice for this level of animation. Online games often use simplified models of simplied computations to help with real-demands.

Now our objective is to figure out the new v1x, v1y, v2x, and v2y. Thus we want to resolve all the angles relative to vertical and horizontal.
The picture below now shows the important angles and how they can be found.



Situation 1:
Yellow stone moving, Red Stone Stopped

Angle a is the angle the moving weight velocity makes with the line of impact.
Angle b is the angle that the line of impact makes with the horizontal.
The angle then that the moving weight would depart would be angle c=b-a.

First remember the old velocity
V = sqrt(v1x*v1x + v1y*v1y);

Here is how the angles can be found.

b = arcsin((y2-y1)/2R) //i.e. computed from the known positions of the stones. //In Java, `Math` class there is an `asin()` method that does this //there also the `sin()` and `cos()` methods. (Javascript has similar math functions available through the `Math` function object).

d = arcsin(vx/V); //moving weight's angle with the vertical

a = pi/2 - b -d //i.e. angle a is 90 degrees less angle b and d; remember we have to work in radians so 90 degrees is pi/2.

So then the angle c at which the moving weight departs at relative to the horizon is: c = b - a.

So now we know all the important angles so let's calculate the new speeds.

The new speeds are:
V1 = V*sin(a); V2 = V*cos(a);

Resolve the speeds back into vertical and horizontal components for the two weights.

v1x = V1*cos(c); v1y = V1*sin(c); v2x = V2*cos(b); v2y = V2*sin(b);

So now the weights are on their way with new speeds and directions and will move when the next timer event occurs.

There are other details you may have to resolve. To handle two weights moving at once you can work out the additional details. It will involve a few more angles and speeds but won't be much harder. The other way you could do two weights moving is to handle it as two cases. In each case one is stopped and the other moving. Then just add the horizontal and vertical velocities of the two cases together at the end and you will have your answer (this is how the demonstration code works).