# PLab Final Report

## Team 5


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|---|---|
| Project Manager: | Meng Yan @ my2316 |
| Language Guru: | Qi Jiang @ qj2113 |
| System Architect: | Yi Zhang @ yz2360 |
| System Integrator: | Tianju Wang @ tw2326 |
| System Tester: | Wei An @ wa2166 |

# Introduction (Meng Yan)

- PLab Language is a programming language which provides a simple and powerful way to simulate physics experiments of Newton's Mechanics *for education purpose*.
- Our goal is to make physics experiments *easy to design, implement and understand*.
- The Expected users of PLab are *teachers of physics* and physic fans.

# Project Timeline (Meng Yan)

| Item | Task | Start Date | End Date | Status |
|---|---|---|---|---|
| **1** | Language Design | | | |
| **1.1** | Brain-storming : Language Design | 2011-2-7 | 2011-2-7 | 100% |
| **1.2** | Set up development environment | 2011-2-10 | 2011-2-10 | 100% |
| **1.3** | White paper | 2011-2-13 | 2011-2-20 | 100% |
| **1.4** | Setting language semantics | 2011-2-27 | 2011-3-7 | 100% |
| **1.5** | Tutorial and Reference Manual | 2011-3-10 | 2011-3-17 | 100% |
| **2** | Translator Implementation | | | |
| **2.1** | Scanner | 2011-3-24 | 2011-4-1 | 100% |
| **2.2** | Parser | 2011-3-26 | 2011-4-1 | 100% |
| **2.3** | System Testing Phase 1 | 2011-4-1 | 2011-4-7 | 100% |
| **3** | IDE and Bug fixing | | | |
| **3.1** | IDE Design | 2011-4-8 | 2011-4-15 | 100% |
| **3.2** | System Testing Phase 2 | 2011-4-15 | 2011-5-1 | 100% |
| **4** | Final Report and Demo | | | |
| **4.1** | Modify white paper, tutorial and reference manual | 2011-4-3 | 2011-4-25 | 100% |
| **4.2** | Final report | 2011-4-25 | 2011-5-2 | 100% |
| **4.3** | Demo preparation | 2011-5-4 | 2011-5-8 | 100% |

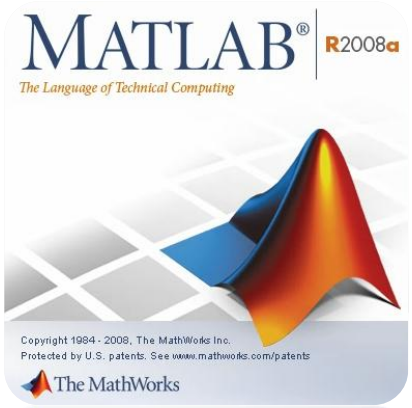
# Language Evolution (Qi Jiang)

***Functionality***:
Simulation
***Domain***:
Education

***Method***:
Object-Oriented
***Structure***:
Section & Element

***Subroutine***:
Branch & Loop
Embedded Script

***TEST, TEST, TEST!!!***




# A Typical PLab Program (Qi Jiang)

```
Environment PS is
Physical_Space {
   Gravity = 9.81;
}

Environment Cam is Camera {
   CamCenter = [0, 30, 30];
   CamDirection = [0, 1, 0];
   CamMoveSpeed = 15;
}

Environment F is Floor {
   Length =20;
   Width = 20;
   Texture = POND;
   Restitution = 1;
}
```

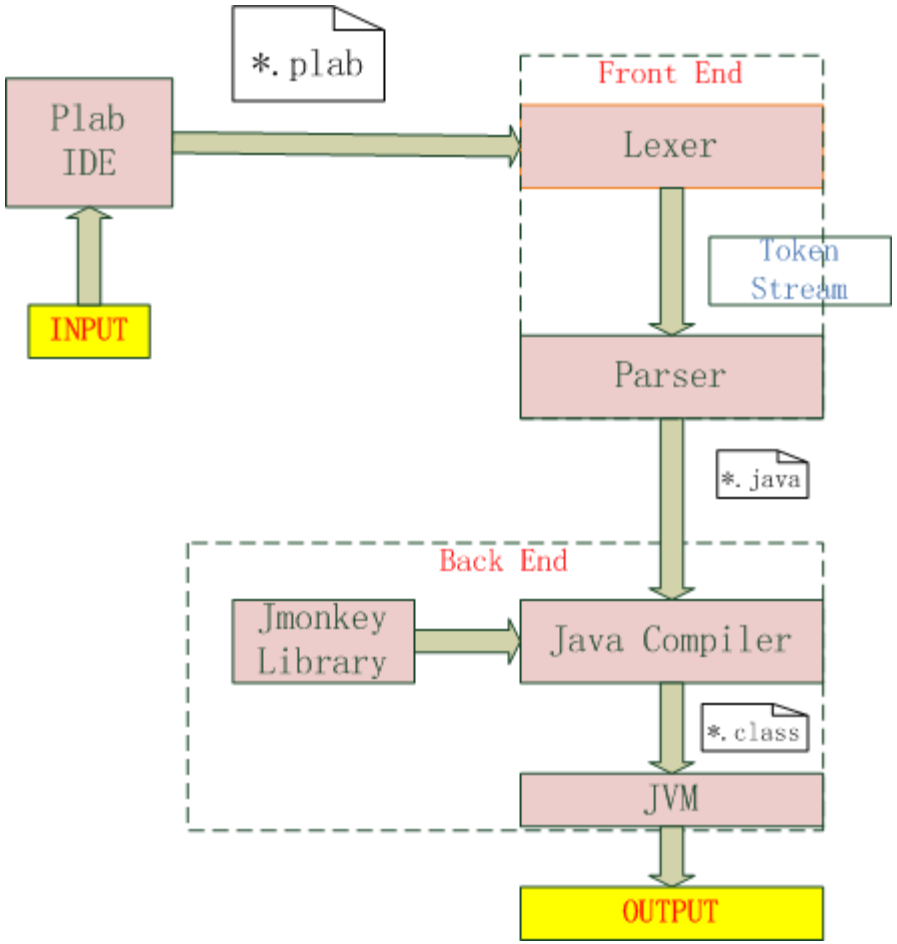
```
Object S1 is Sphere {
   Radius = 0.5;
   Center = [-10, 1.5, 0];
   Color = PINK;
   Mass = 10;
}

Object Item is Box {
   Extent = [6, 0.01, 0.5];
   Center = [0, 2, 0];
   Rotation = [0, 0, 30];
   Texture = WALL;
   Mass = 0;
}
```

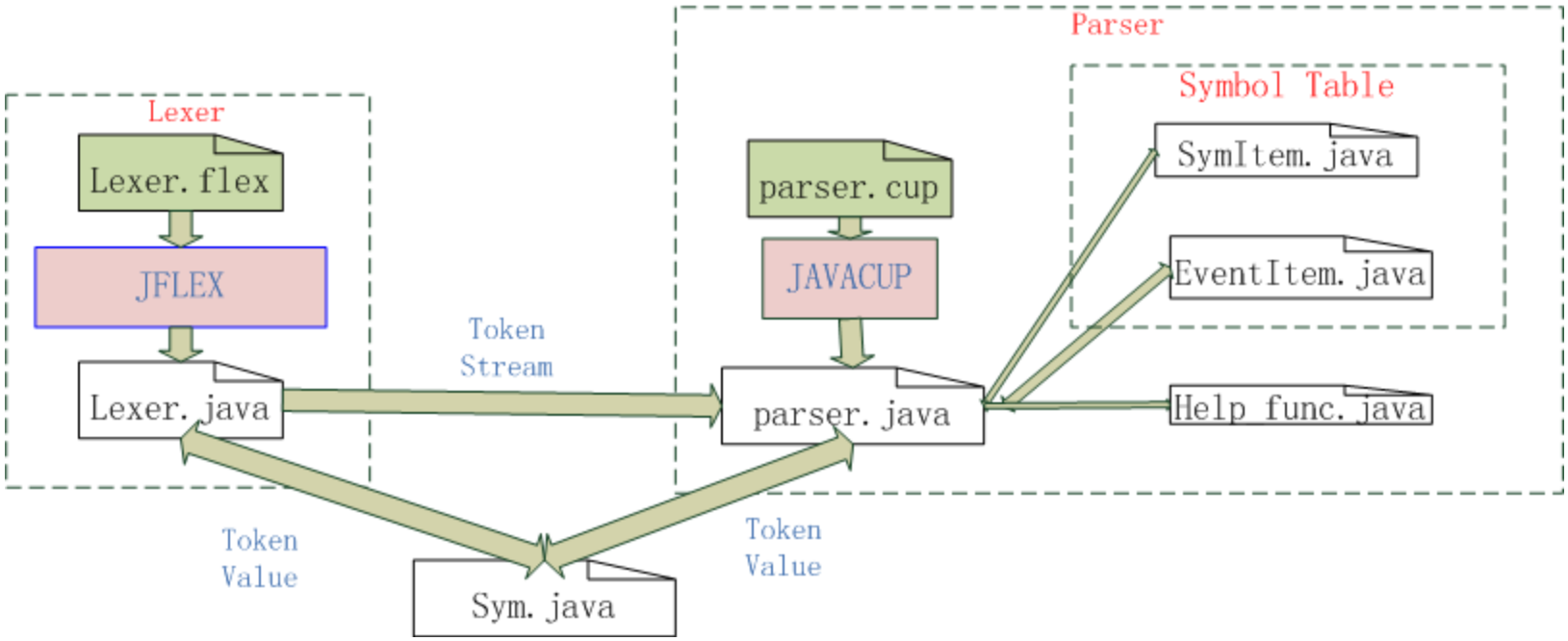
```
Event C is Collision {
   CollisionA = Floor;
   CollisionB = S1;
   Action = M;
}

Event M is Modification {
   Item.Color = RANDOMCOLOR;
   S1.Velocity = [0, 0, 5];
}
```

# Translator Architecture (Yi Zhang)



# Translator Architecture (Yi Zhang)

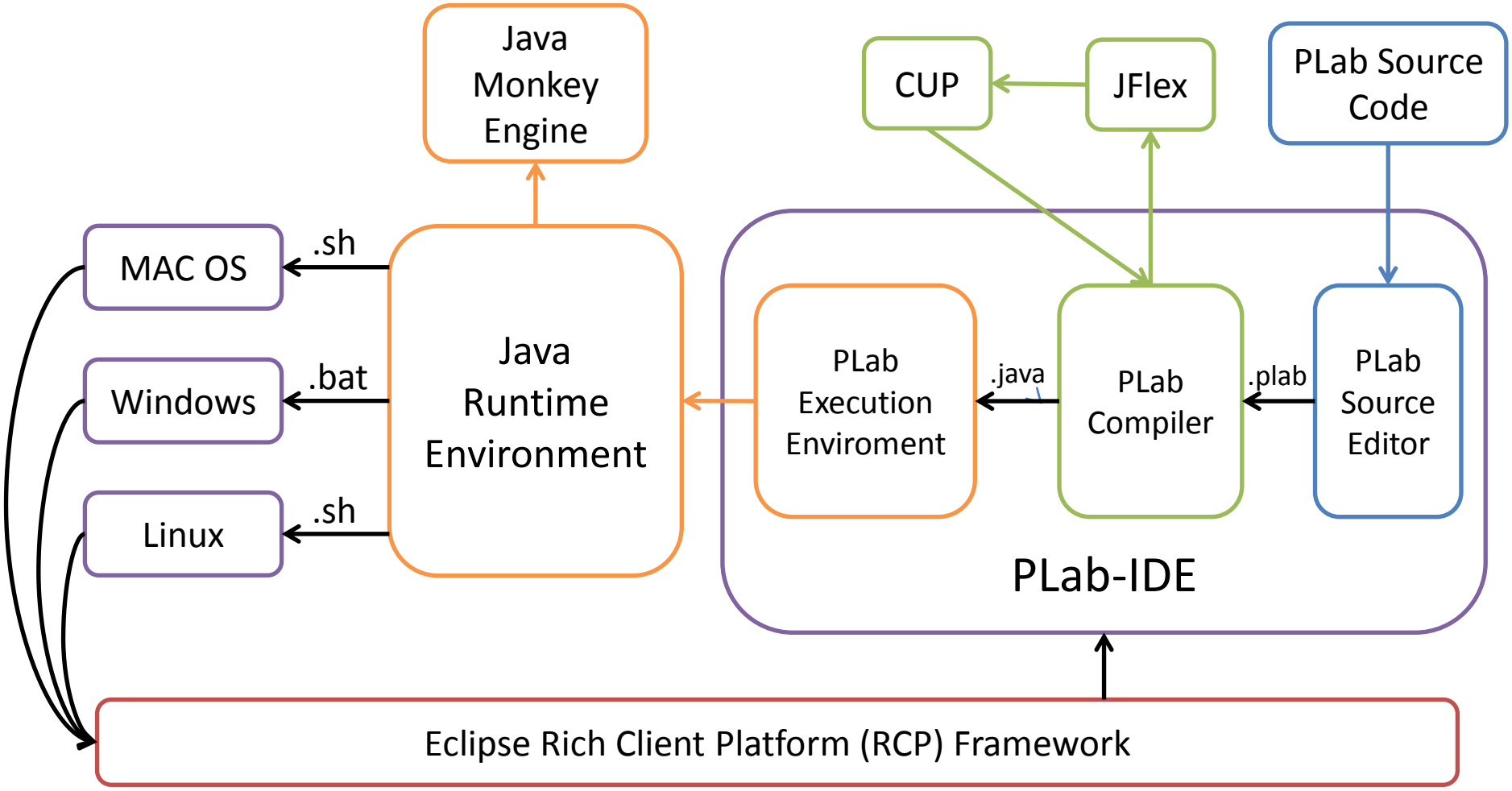


# Development Tools (Tianju Wang)

| | | |
|---|---|---|
| Development Language | Java | JVM Version: 1.6 Update 22 |
| Develop Environment | Eclipse for RCP Developers | Version: Helios Service Release 2 |
| Version Control Tool | Subversion | Service Provided by Google Code |
| Document Maintains | Google Doc | Word and Spreadsheet |
| Operating System | Mac OS<br>Windows 7 | 10.6. (Snow Leopard)<br>Home Edition/Ultimate |

- Cross Platform
- Easy Deployment
- Team Cooperation
- Java Monkey Engine
- JFlex/CUP Parser
- Eclipse RCP

# System Architecture (Tianju Wang)



# PLab Test Plan (Wei An)

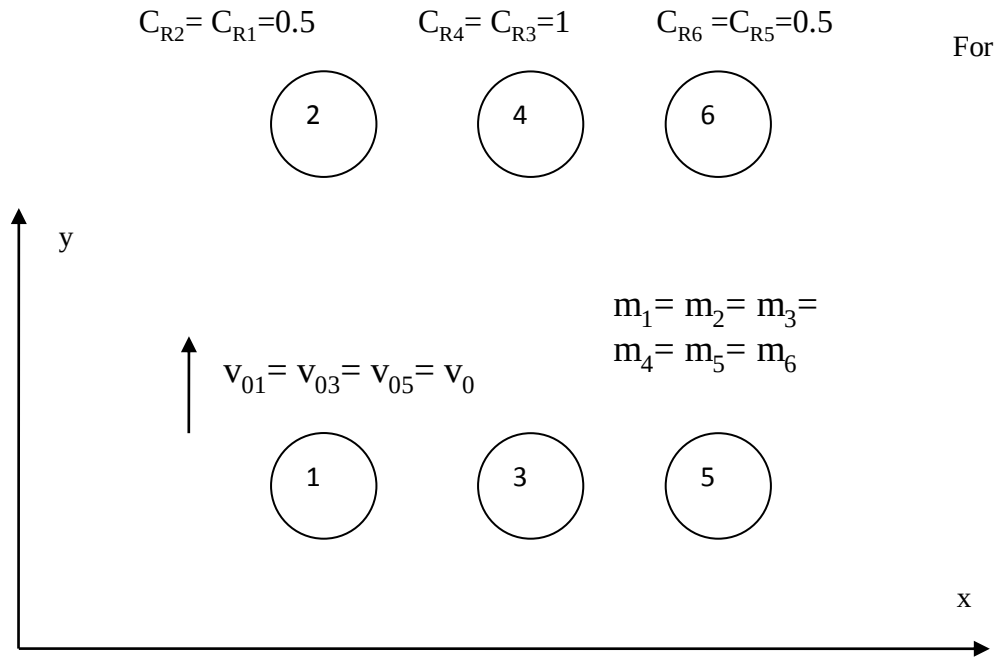
| Section | File Name | Element/Attribute Type | Usage |
|---|---|---|---|
| **Environment** | TestEnvironment | Physical_Space, Camera, Floor | Test if the environment section works |
| | TestEnvironment_Light | Light | Test the environment with and without shadow |
| **Object** | TestObject_Shape | Sphere, Box, Cylinder, Dome | Constructing different types of objects |
| | TestObject_Motion | Velocity, Center | Various linear velocities |
| | TestObject_AngularMotion | Angular_Velocity | Various angular velocities |
| **Global** | TestGlobalAttr_Texture | Texture | Testing Global attribute Texture in Environment and Object section |
| | TestGlobalAttr_Color | Color | Testing Global attribute Color in Environment and Object section |
| **Event** | TestEvent_Force | Force | Force acting on the Center and other positions of an Object |
| | TestEvent_Trigger | Trigger | Velocity, Angular_Velocity, and Time in Expression |
| | TestEvent_Trigger2 | Trigger | Center and x, y, z of a vector |
| | TestEvent_Modification | Modification | Modification on Center, Rotation, Velocity, Angular_Velocity, Color, and Texture |
| | TestEvent_Collision1 | Collison | Action is Force or Modification |
| | TestEvent_Collision2 | Collison | Collision time is used in Trigger |
| **Script** | TestScript_$and$$ | $ and $$ | Inserting lines of scrip or tokens in PLab |
| | TestScript_if | if | Usage of if, then, else, elseif, endif |
| | TestScript_for | for | Usage of for, do, endfor |

# PLab Test Plan (Wei An)

| Physics Section | File Name | Description |
|---|---|---|
| Gravity | TestPhysics_Freefall | The freefall motion of objects near earth |
| Newton's Second Law | TestPhysics_Projectile | The motion of projectiles with the same initial speed and different projectile angle |
| Friction | TestPhysics_Friction | Static friction, kinetic friction, and rolling resistance |
| Collision | TestPhysics_Collision | Collision with different coefficient of restitution. (Perfect inelastic collision, inelastic collision, and elastic collision) |
| Uniform Circular Motion | TestPhysics_Orbit | Uniform circular motion with different trajectory. |
| Newton's Law of Universal Gravitation | TestPhysics_EscapeV | Escape velocity (second cosmic velocity) and circular orbit velocity (first cosmic velocity). |

# Demo: Collision (Wei An)

We designed this experiment for elastic and inelastic collisions. And give different coefficients of restitution to see the phenomena of the collisions.




For perfect inelastic collision: $m_a u_a + m_b u_b = (m_a + m_b) v$

$$v = \frac{m_a u_a + m_b u_b}{m_a + m_b}$$

For perfect elastic collision:

$$\begin{cases} m_a u_a + m_b u_b = m_a v_a + m_b v_b \\ \frac{m_a u_a^{\,2}}{2} + \frac{m_b u_b^{\,2}}{2} = \frac{m_a v_a^{\,2}}{2} + \frac{m_b v_b^{\,2}}{2} \end{cases}$$

$$\begin{cases} v_a = \frac{(m_a - m_b) u_a + 2 m_b u_b}{m_a + m_b} \\ v_b = \frac{(m_b - m_a) u_b + 2 m_a u_a}{m_a + m_b} \end{cases}$$

$$v_a = \frac{m_a u_a + m_b u_b + m_b C_R (u_b - u_a)}{m_a + m_b}$$

$$v_b = \frac{m_a u_a + m_b u_b + m_a C_R (u_a - u_b)}{m_a + m_b}$$

# Demo: Escape Velocity (Wei An)

We test the phenomena of escape velocity and orbit velocity in the test cases. Let GM=1000, m=1, $r_0$=10. We give the initial values of $|v_o|$ from 7 to 15

From Newton's Gravitational Law,

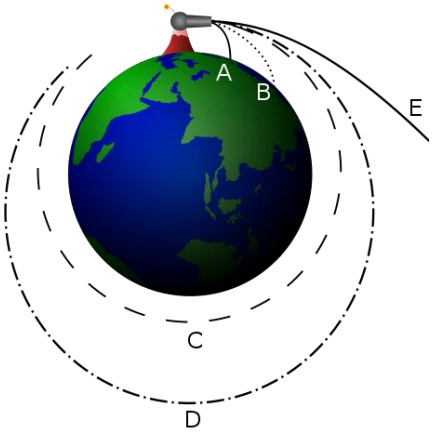
$$F_G = ma = m\frac{\mathrm{d}v}{\mathrm{d}t} = -\frac{GMm}{r^2}$$

$$a = \frac{\mathrm{d}v}{\mathrm{d}t} = -\frac{GM}{r^2} = \frac{\mathrm{d}v}{\mathrm{d}r}\cdot\frac{\mathrm{d}r}{\mathrm{d}t} = \frac{\mathrm{d}v}{\mathrm{d}r}\cdot v$$

So

$$v\cdot\mathrm{d}v = -\frac{GM}{r^2}\mathrm{d}r$$

$$\Rightarrow \int_{v_0}^{+\infty} v\cdot\mathrm{d}v = -\int_{r_0}^{+\infty}\frac{GM}{r^2}\mathrm{d}r$$




Solve this equation, we get

$$-\frac{1}{2}v_0^{\,2} = -\frac{GM}{r_0}$$

$$\Rightarrow v_e = v_0 = \sqrt{\frac{2GM}{r_0}}$$

We derive the circular orbit velocity

$$F_G = -m\frac{v^2}{r_0} = -\frac{GMm}{r_0^{\,2}}$$

$$\Rightarrow v_o = v = \sqrt{\frac{GM}{r_0}}$$