Homework 4: Mutation Based Testing

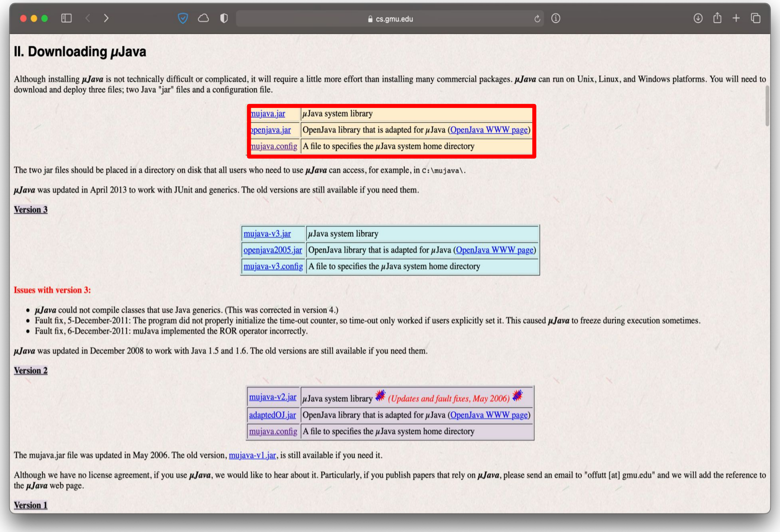
Software Testing 2022

2022/05/26

muJava

muJava

➔ Download **mujava.jar**, **openjava.jar** and **mujava.config**
  - From: https://cs.gmu.edu/~offutt/mujava/



II. Downloading μJava

Although installing ***μJava*** is not technically difficult or complicated, it will require a little more effort than installing many commercial packages. ***μJava*** can run on Unix, Linux, and Windows platforms. You will need to download and deploy three files; two Java "jar" files and a configuration file.

mujava.jar	μJava system library
openjava.jar	OpenJava library that is adapted for μJava (OpenJava WWW page)
mujava.config	A file to specifies the μJava system home directory

The two jar files should be placed in a directory on disk that all users who need to use ***μJava*** can access, for example, in `C:\mujava\`.

μJava was updated in April 2013 to work with JUnit and generics. The old versions are still available if you need them.

Version 3

mujava-v3.jar	μJava system library
openjava2005.jar	OpenJava library that is adapted for μJava (OpenJava WWW page)
mujava-v3.config	A file to specifies the μJava system home directory

Issues with version 3:

- ***μJava*** could not compile classes that use Java generics. (This was corrected in version 4.)
- Fault fix, 5-December-2011: The program did not properly initialize the time-out counter, so time-out only worked if users explicitly set it. This caused ***μJava*** to freeze during execution sometimes.
- Fault fix, 6-December-2011: muJava implemented the ROR operator incorrectly.

μJava was updated in December 2008 to work with Java 1.5 and 1.6. The old versions are still available if you need them.

Version 2

mujava-v2.jar	μJava system library *(Updates and fault fixes, May 2006)*
adaptedOJ.jar	OpenJava library that is adapted for μJava (OpenJava WWW page)
mujava.config	A file to specifies the μJava system home directory

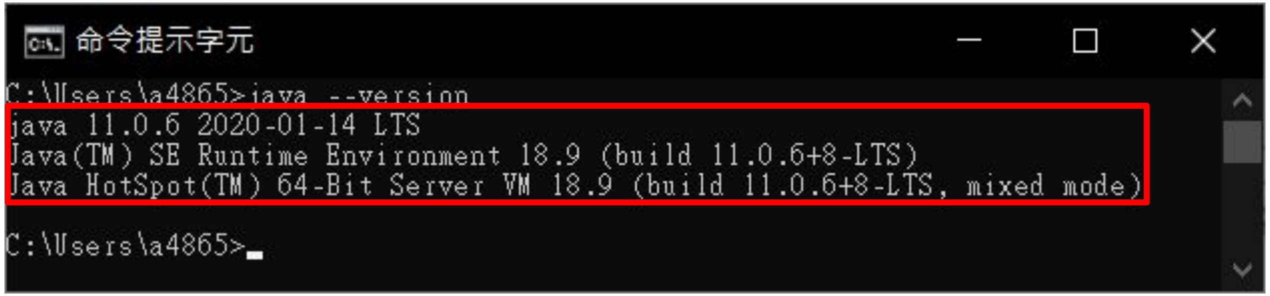
The mujava.jar file was updated in May 2006. The old version, mujava-v1.jar, is still available if you need it.

Although we have no license agreement, if you use ***μJava***, we would like to hear about it. Particularly, if you publish papers that rely on ***μJava***, please send an email to "offutt [at] gmu.edu" and we will add the reference to the ***μJava*** web page.

Version 1

Installation - Windows 10

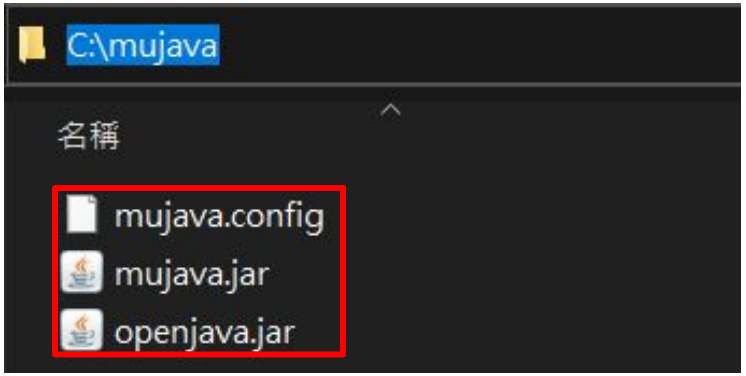
- Step 1 :
  - check jdk version (at least 1.8)
    - **$ java --version**



```
C:\Users\a4865>java --version
java 11.0.6 2020-01-14 LTS
Java(TM) SE Runtime Environment 18.9 (build 11.0.6+8-LTS)
Java HotSpot(TM) 64-Bit Server VM 18.9 (build 11.0.6+8-LTS, mixed mode)

C:\Users\a4865>
```

Installation - Windows 10

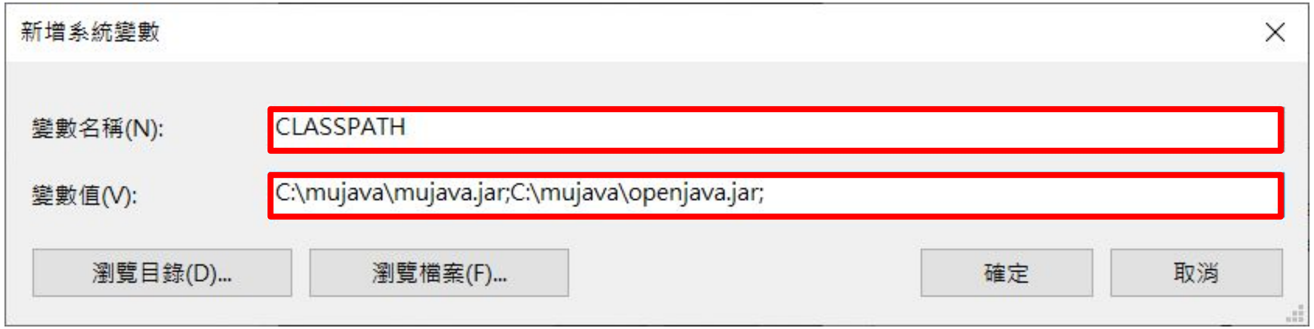
➔ Step 2 :
  - Put the file in here :
    - C:\mujava


C:\mujava

mujava.config
mujava.jar
openjava.jar

Installation - Windows 10

- Step 3 :
  - Set CLASSPATH
    - **本機 → 內容 → 進階系統設定 → 進階 → 環境變數 → 系統變數 → 新增**
      - 變數名稱: CLASSPATH
      - 變數值: C:\mujava\mujava.jar;C:\mujava\openjava.jar;

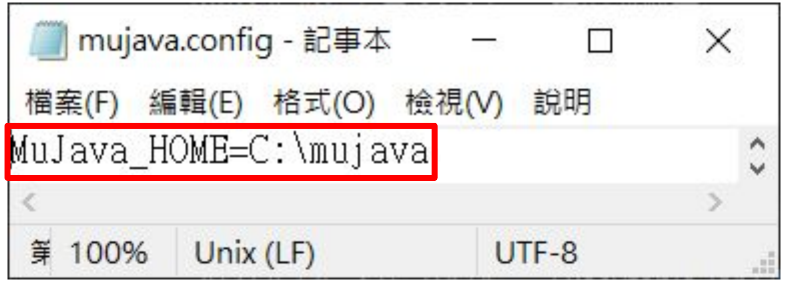

新增系統變數

變數名稱(N): CLASSPATH

變數值(V): C:\mujava\mujava.jar;C:\mujava\openjava.jar;

Installation - Windows 10

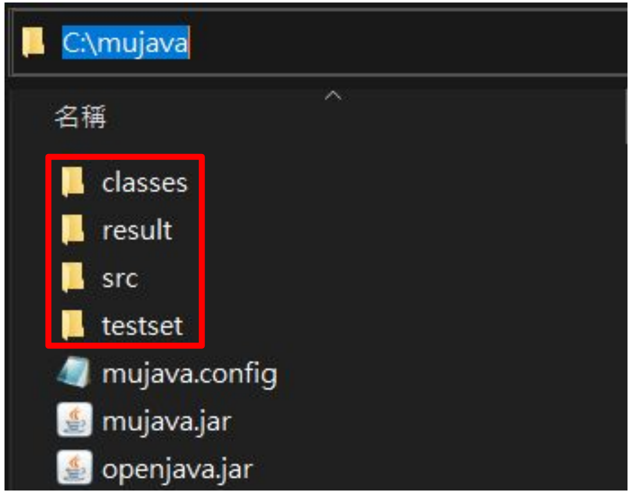
- Step 4 :
  - Modify the content of ***mujava.config***
    - MuJava_HOME=C:\mujava



```
MuJava_HOME=C:\mujava
```

Installation - Windows 10

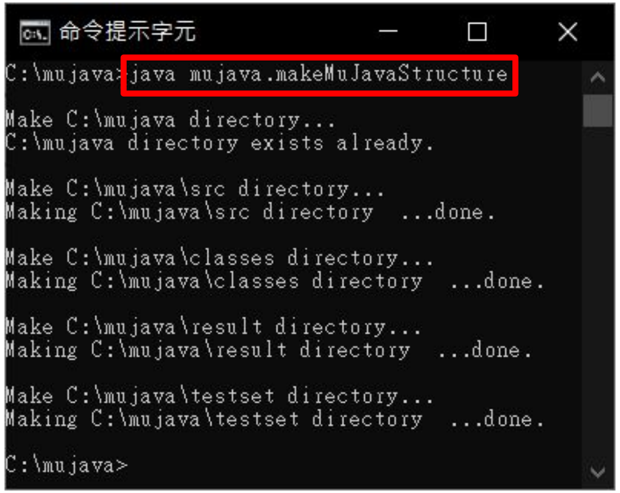
➔ Step 5 :
  - Create these four folders


C:\mujava

classes
result
src
testset
mujava.config
mujava.jar
openjava.jar

Installation - Windows 10

- ➔ Step 5 :
  - ◆ Or, can use cmd create
    - ● **$ java mujava.makeMuJavaStructure**

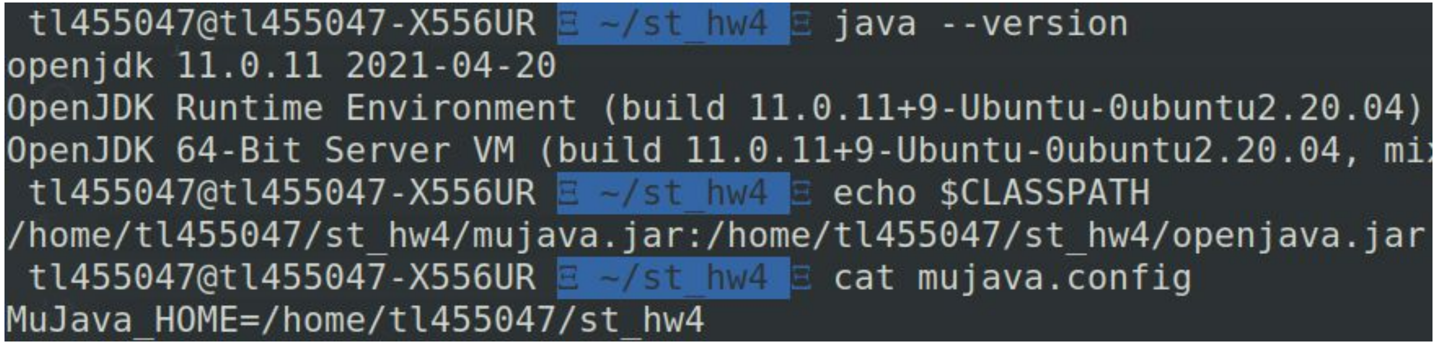


命令提示字元

```
C:\mujava>java mujava.makeMuJavaStructure

Make C:\mujava directory...
C:\mujava directory exists already.

Make C:\mujava\src directory...
Making C:\mujava\src directory  ...done.

Make C:\mujava\classes directory...
Making C:\mujava\classes directory  ...done.

Make C:\mujava\result directory...
Making C:\mujava\result directory  ...done.

Make C:\mujava\testset directory...
Making C:\mujava\testset directory  ...done.

C:\mujava>
```

Installation - Ubuntu 20.04

- Steps
  - install openjdk-11
    - sudo apt-get install openjdk-11-jdk
  - export CLASSPATH
    - export CLASSPATH=/DIR/mujava.jar:/DIR/openjava.jar
  - set mujava.config
    - MuJava_HOME=/DIR

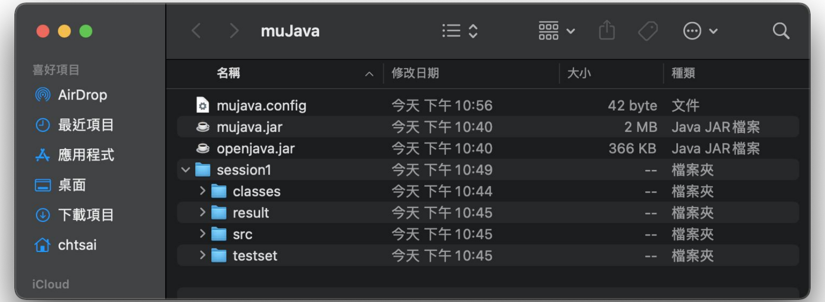


```
 tl455047@tl455047-X556UR  ~/st_hw4  java --version
openjdk 11.0.11 2021-04-20
OpenJDK Runtime Environment (build 11.0.11+9-Ubuntu-0ubuntu2.20.04)
OpenJDK 64-Bit Server VM (build 11.0.11+9-Ubuntu-0ubuntu2.20.04, mi
 tl455047@tl455047-X556UR  ~/st_hw4  echo $CLASSPATH
/home/tl455047/st_hw4/mujava.jar:/home/tl455047/st_hw4/openjava.jar
 tl455047@tl455047-X556UR  ~/st_hw4  cat mujava.config
MuJava_HOME=/home/tl455047/st_hw4
```

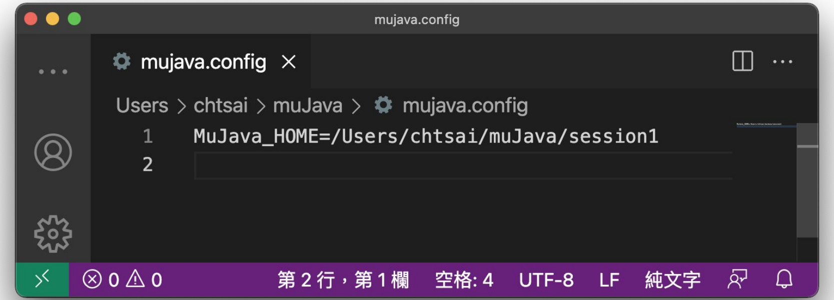
Installation - macOS 11.4

➔ Steps

- $ export CLASSPATH=$CLASSPATH:/Users/chtsai/muJava/mujava.jar:/Users/chtsai/muJava/openjava.jar
  - e.g. /Users/chtsai/muJava
- $ java --version
  - openjdk 11.0.9 2020-10-20
  - OpenJDK Runtime Environment (build 11.0.9+11)
  - OpenJDK 64-Bit Server VM (build 11.0.9+11, mixed mode)



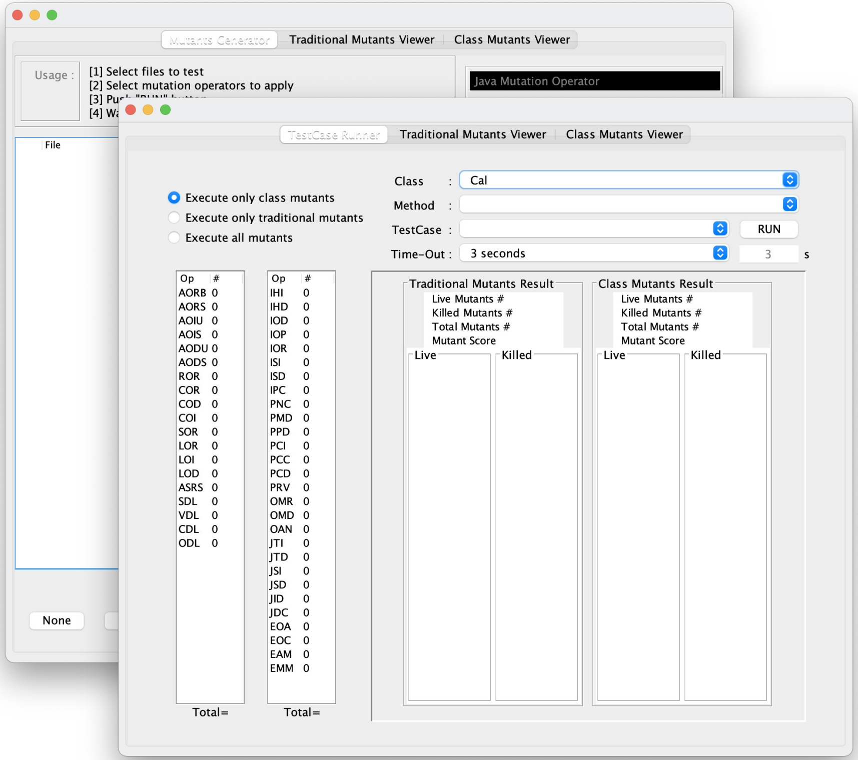
名稱	修改日期	大小	種類
mujava.config	今天 下午 10:56	42 byte	文件
mujava.jar	今天 下午 10:40	2 MB	Java JAR檔案
openjava.jar	今天 下午 10:40	366 KB	Java JAR檔案
session1	今天 下午 10:49	--	檔案夾
classes	今天 下午 10:44	--	檔案夾
result	今天 下午 10:45	--	檔案夾
src	今天 下午 10:45	--	檔案夾
testset	今天 下午 10:45	--	檔案夾



```
MuJava_HOME=/Users/chtsai/muJava/session1

```

Homework

- ➔ Installation TL;DR
  - a. Get Java version
  - b. Export CLASSPATH
    - ● jar files
  - c. Set muJava configuration
    - ● specify muJava home directory
- ➔ Run muJava
  - a. $ java mujava.gui.GenMutantsMain
  - b. $ java mujava.gui.RunTestMain



Usage : [1] Select files to test
[2] Select mutation operators to apply
[3] Pu
[4] Wa

[✓ Execute only class mutants]
Execute only traditional mutants
Execute all mutants

Class : Cal
Method :
TestCase :
Time-Out : 3 seconds 3 s

Op	#
AORB	0
AORS	0
AOIU	0
AOIS	0
AODU	0
AODS	0
ROR	0
COR	0
COD	0
COI	0
SOR	0
LOR	0
LOI	0
LOD	0
ASRS	0
SDL	0
VDL	0
CDL	0
ODL	0

Total=

Op	#
IHI	0
IHD	0
IOD	0
IOP	0
IOR	0
ISI	0
ISD	0
IPC	0
PNC	0
PMD	0
PPD	0
PCI	0
PCC	0
PCD	0
PRV	0
OMR	0
OMD	0
OAN	0
JTI	0
JTD	0
JSI	0
JSD	0
JID	0
JDC	0
EOA	0
EOC	0
EAM	0
EMM	0

Total=

Traditional Mutants Result
Live Mutants #
Killed Mutants #
Total Mutants #
Mutant Score
Live
Killed

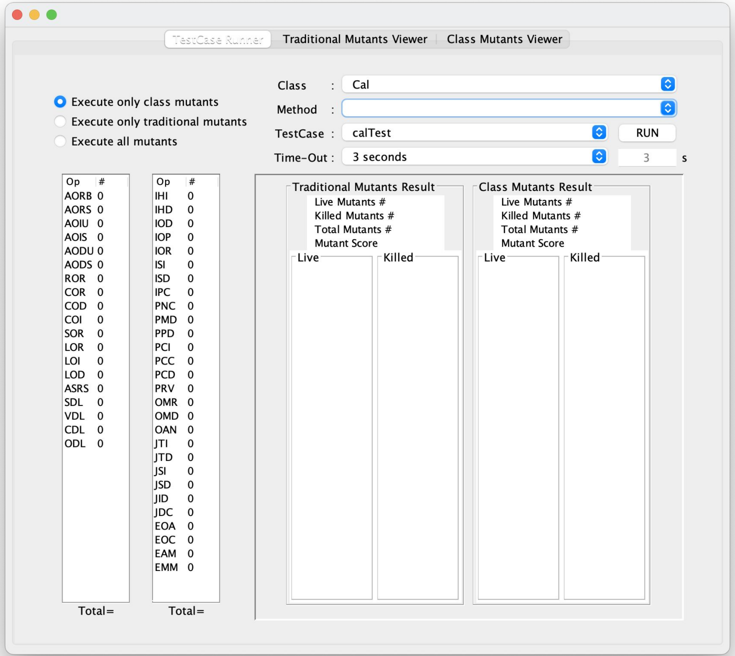
Class Mutants Result
Live Mutants #
Killed Mutants #
Total Mutants #
Mutant Score
Live
Killed

Hint

1. Junit 4 only
   a. export CLASSPATH
      i. junit-4.12.jar
      ii. hamcrest-core-1.3.jar

2. Method is blank
   a. choose **“class” list** first

3. TestCase is blank
   a. write test cases (CalTest.java) and compile
      i. javac CalTest.java ../src/Cal.java
   b. location
      i. */muJava/session1/testset/CalTest.class



[✓ Execute only class mutants] Execute only traditional mutants / Execute all mutants

Class : Cal
Method :
TestCase : calTest
Time-Out : 3 seconds   3 s

Op	#
AORB	0
AORS	0
AOIU	0
AOIS	0
AODU	0
AODS	0
ROR	0
COR	0
COD	0
COI	0
SOR	0
LOR	0
LOI	0
LOD	0
ASRS	0
SDL	0
VDL	0
CDL	0
ODL	0

Total=

Op	#
IHI	0
IHD	0
IOD	0
IOP	0
IOR	0
ISI	0
ISD	0
IPC	0
PNC	0
PMD	0
PPD	0
PCI	0
PCC	0
PCD	0
PRV	0
OMR	0
OMD	0
OAN	0
JTI	0
JTD	0
JSI	0
JSD	0
JID	0
JDC	0
EOA	0
EOC	0
EAM	0
EMM	0

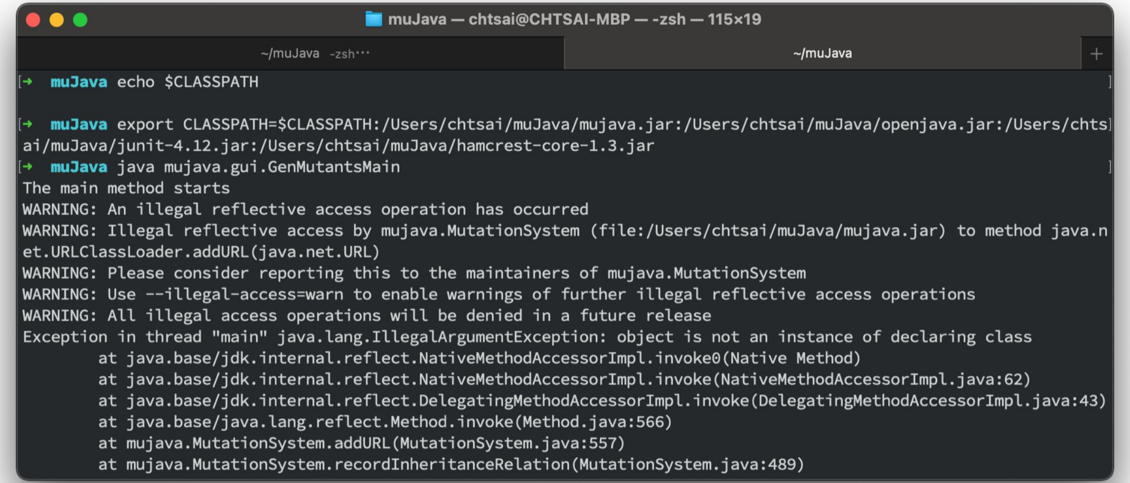
Total=

Traditional Mutants Result
Live Mutants #
Killed Mutants #
Total Mutants #
Mutant Score
Live   Killed

Class Mutants Result
Live Mutants #
Killed Mutants #
Total Mutants #
Mutant Score
Live   Killed

Hint

4. **After** GenMutantsMain
   a. Avoid score is always 100%
   b. Prevent the warning
   c. **cp */muJava/session1/src/Cal.class */muJava/session1/classes**



muJava — chtsai@CHTSAI-MBP — -zsh — 115×19

```
→  muJava echo $CLASSPATH

→  muJava export CLASSPATH=$CLASSPATH:/Users/chtsai/muJava/mujava.jar:/Users/chtsai/muJava/openjava.jar:/Users/chts
ai/muJava/junit-4.12.jar:/Users/chtsai/muJava/hamcrest-core-1.3.jar
→  muJava java mujava.gui.GenMutantsMain
The main method starts
WARNING: An illegal reflective access operation has occurred
WARNING: Illegal reflective access by mujava.MutationSystem (file:/Users/chtsai/muJava/mujava.jar) to method java.n
et.URLClassLoader.addURL(java.net.URL)
WARNING: Please consider reporting this to the maintainers of mujava.MutationSystem
WARNING: Use --illegal-access=warn to enable warnings of further illegal reflective access operations
WARNING: All illegal access operations will be denied in a future release
Exception in thread "main" java.lang.IllegalArgumentException: object is not an instance of declaring class
        at java.base/jdk.internal.reflect.NativeMethodAccessorImpl.invoke0(Native Method)
        at java.base/jdk.internal.reflect.NativeMethodAccessorImpl.invoke(NativeMethodAccessorImpl.java:62)
        at java.base/jdk.internal.reflect.DelegatingMethodAccessorImpl.invoke(DelegatingMethodAccessorImpl.java:43)
        at java.base/java.lang.reflect.Method.invoke(Method.java:566)
        at mujava.MutationSystem.addURL(MutationSystem.java:557)
        at mujava.MutationSystem.recordInheritanceRelation(MutationSystem.java:489)
```