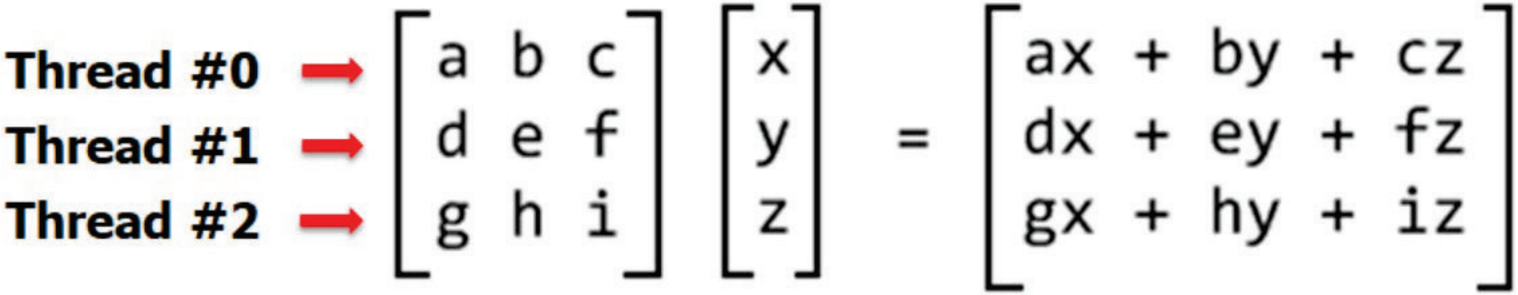
Lab Exercise

- **Matrix-vector multiplication using multi-threading**
  - Product of **M*N matrix** and **N*1 vector** is **M*1 vector**
  - Row size (**M**) and column size (**N**) of matrix are given as command line arguments
  - Elements of matrix and vector are randomly generated between **0~9** (data type is **uint8_t**)
  - **Create M threads where M is the row size**
  - **Each thread performs a calculation on one row of the matrix**
  - **thread_data struct** is used to store calculation result (**uint64_t**) and read the vector, matrix row, and column size (**N**).
  - Main function must wait other threads to terminate

Lab Exercise Hint

- **Matrix-Vector multiplication**



$$\begin{bmatrix} a & b & c \\ d & e & f \\ g & h & i \end{bmatrix} \begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} ax + by + cz \\ dx + ey + fz \\ gx + hy + iz \end{bmatrix}$$

- `#include <time.h>`
  - `srand(time(NULL));`
  - `int a = rand() % 10;`

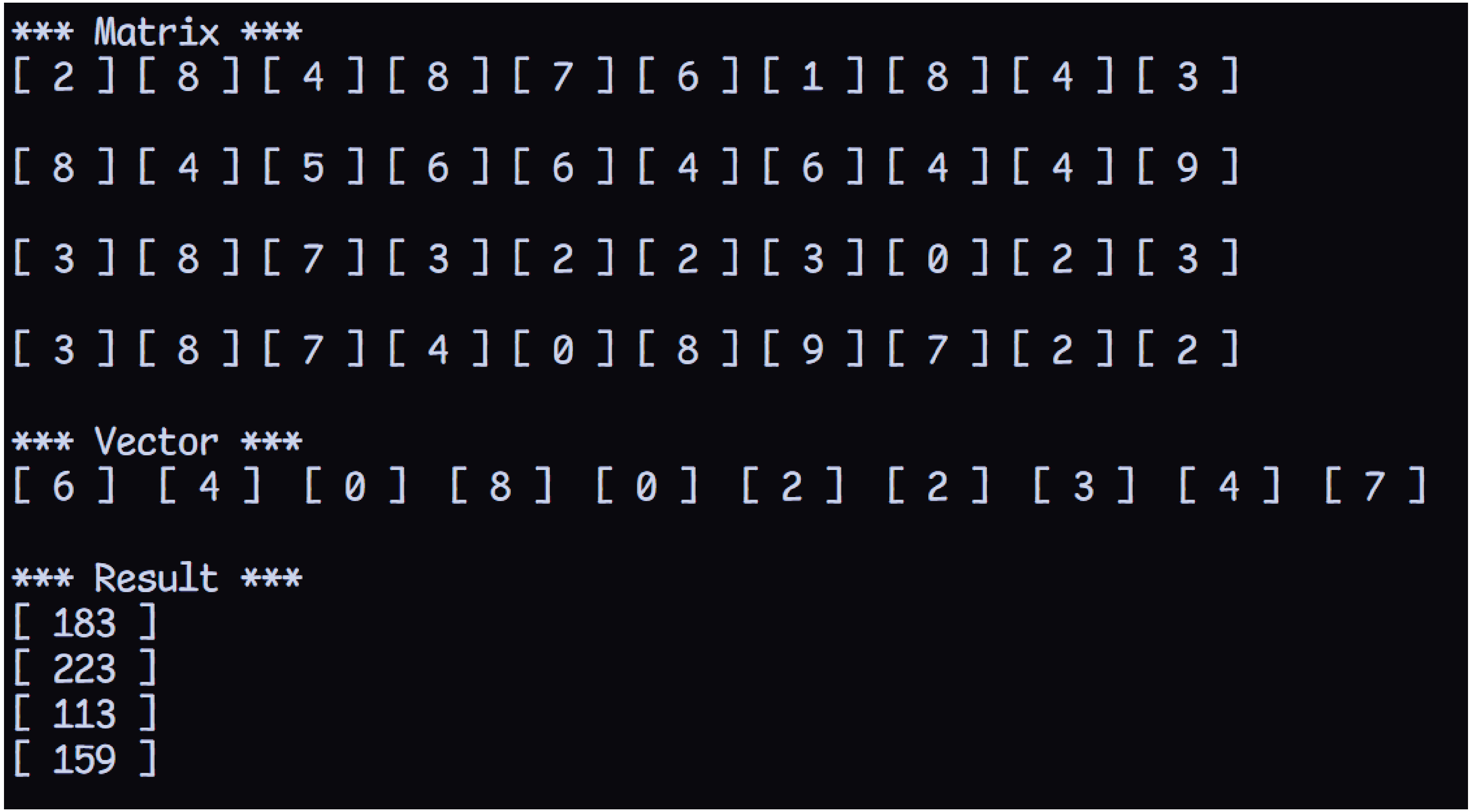
- **Skeleton Code : iCampus**

Lab Exercise Hint

- **A function is provided to print the expected results of the matrix-vector multiplication and an error if the results are not expected.**
  - To compile a program that uses this function, you have to define DEBUG (just like _GNU_SOURCE) either by adding –DDEBUG as a compiler option in your Makefile (i.e. gcc –DDEBUG) or adding “#define DEBUG” on top.

Lab Exercise

- **Running Example**



```
*** Matrix ***
[ 2 ] [ 8 ] [ 4 ] [ 8 ] [ 7 ] [ 6 ] [ 1 ] [ 8 ] [ 4 ] [ 3 ]

[ 8 ] [ 4 ] [ 5 ] [ 6 ] [ 6 ] [ 4 ] [ 6 ] [ 4 ] [ 4 ] [ 9 ]

[ 3 ] [ 8 ] [ 7 ] [ 3 ] [ 2 ] [ 2 ] [ 3 ] [ 0 ] [ 2 ] [ 3 ]

[ 3 ] [ 8 ] [ 7 ] [ 4 ] [ 0 ] [ 8 ] [ 9 ] [ 7 ] [ 2 ] [ 2 ]

*** Vector ***
[ 6 ]  [ 4 ]  [ 0 ]  [ 8 ]  [ 0 ]  [ 2 ]  [ 2 ]  [ 3 ]  [ 4 ]  [ 7 ]

*** Result ***
[ 183 ]
[ 223 ]
[ 113 ]
[ 159 ]
```

Exercise Submission

- **Submit your source code and Makefile**
  - The *make* command should generate a *w12* executable.
  - via iCampus
  - Bundle ***source code*** and ***Makefile*** with tar command
    - » *tar.gz* format

      $ tar cvzf *[student_id].tar.gz week12*
  - We'll grade your submission with **make**
    - » If compilation fails, your points for this exercise will be zero