Background

Most muscles fall into two muscle types, parallel and pennate. Parallel muscles are the most common, with the muscle fibers coaxial with the muscle contraction. Pennate muscles have muscle fibers which pull at an angle to the muscle axis, which allows a higher force to be generated for a given volume of muscle.

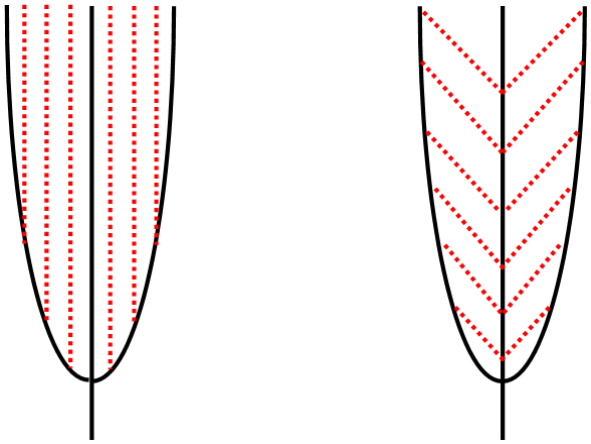

Figure 1: Depiction of parallel muscle fibers (left) and pennate muscle fibers (right).

The forces generated by each type of muscle are described by the equations below, where f is the force per unit area produced by the muscle fibers, F is the total force produced by the muscle, and α (alpha) is the angle between the muscle fibers and the muscle axis. a, w, and l describe the physical size of the muscles.

$$F_{parallel} = 2 * a * w * f$$

$$F_{pennate} = 2 * w * f * l * \cos(\alpha) * \sin(\alpha)$$

Although the force generated is higher, pennate muscle contracts a shorter distance for a given change in length of the muscle fibers. The relationship between the contraction of parallel and pennate muscles is described by the equation below, where C is the change in length of the muscle during contraction.

$$C_{ratio} = \frac{C_{pennate}}{C_{parallel}} = \sin(\alpha)$$

Problem Statement

You are working with a biomedical engineer to compare the contractile force of two muscles, the *rectus femoris* and *vastus intermedius*. The *rectus femoris* muscle is a pennate muscle, and the *vastus intermedius* muscle is a parallel muscle.

Instructions

Represent

- Consider creating a flowchart, algorithm, or pseudocode for solving the problem.

Plan

- Consider outlining the steps your program will take by adding comment statements to your file based on the flowchart, algorithm, or pseudocode.

Implement

- Your program must use the structs and function prototypes shown below:

```
struct Parallel
{
   //Input variables
   char name[30];
   float w,f,l,a;
   //Result variables
   float force;
};

struct Pennate
{
   //Input variables
   char name[30];
   float w,f,l,alpha;
   //Result variables
   float force, C_ratio;
};

void setvals(struct Parallel *, struct Pennate *);
void calculate(struct Parallel *, struct Pennate *);
void present(struct Parallel, struct Pennate);
```

- Write a complete C/C++ program **APP_C33_1.cpp** to perform the following tasks:
  - Create an instance of each struct type, one for rectus femoris (pennate) and one for vastus intermedius (parallel)
  - Create function **`setvals()`**, which prompts the user to enter all of the input variables for both muscles, and stores the values appropriately
  - Create function **`calculate()`**, which calculates the result variables for both muscles, and stores the values appropriately
  - Create function **`present()`**, which presents the user with the muscle names and corresponding forces, and states the % contraction of the pennate muscle compared to the parallel muscle
  - Within the **`main()`** function, call each function to perform their associated tasks, and test the program with the following test conditions:

Parameter	Parallel muscle	Pennate muscle
w	5.0	5.0
f	2.5	2.5
l	7.0	7.0
a or alpha	2.0	0.785

- You may consider using the `cos()` and `sin()` functions, which are included in the `<math.h>` library.
- Compile, link, and run your program.

Evaluate

- Perform a hand calculation to verify and check your results.

Document

- Create a single PDF that includes your code, output to the terminal, and your verification.
- Submit the PDF to Carmen according to the DAL.

Include the standard comment, **`printf(),`** and **`fprintf()`** statements indicating name, seat number, etc.