3.9 Example: Toll calculation

Calculating toll based on time of day

The section presents an example program that calculates the toll amount for travel along a toll road or toll lane. The toll amount is based on the time of day, day of the week, and number of persons in the vehicle.

The initial version of the program calculates the toll amount for travel on a weekday based upon the toll schedule below. The table lists times in both am/pm format and 24-hour format.

Table 3.9.1: Weekday toll schedule.

Time (am/pm)	Time (24 hour)	Toll amount
Before 6:00 am	Before 6:00	1.55
6:00 am to 9:59 am	6:00 to 9:59	4.65
10:00 am to 5:59 pm	10:00 to 17:59	2.35
6:00 pm and after	18:00 and after	1.55

Feedback?

The program gets the time of travel from the user using 24 hours format, and uses the hour to determine the toll amount. A multi-branch if-else statement is used to determine in which range the hour belongs and assigns tollAmount with the toll based on the table above, and outputs the toll.

Figure 3.9.1: Calculating toll based on time of day.

```
#include <iostream>
#include <iomanip>
using namespace std;

int main() {
   int timeHour;      // Time of travel hour
   int timeMinute;    // Time of travel minute
   char inputColon;   // Used to read time format
   double tollAmount;

   cout << "Enter time of travel (HH:MM in 24 hour format): ";

   // Read an integer (hour), colon (char), and integer (minute)
   cin  >> timeHour >> inputColon >> timeMinute;

   // Determine toll based on hour of travel
   if (timeHour < 6) {         // Before 6:00 am
      tollAmount = 1.55;
   }
   else if (timeHour < 10) {   // 6 am to 9:59 am
      tollAmount = 4.65;
   }
   else if (timeHour < 18) {   // 10 am to 5:59 pm
      tollAmount = 2.35;
   }
   else {                      // 6 pm and after
      tollAmount = 1.55;
   }

   // Output time and toll amount
   cout << "Toll at " << timeHour << ":";

   // Output minute with formatting (discussed elsewhere) to
   // print two digits for minutes.
   cout << setw(2) << setfill('0') << timeMinute;
   cout << " is " << tollAmount << endl;

   return 0;
}
```

```
Enter time of travel (HH:MM in 24 hour format): 9:30
Toll at 9:30 is 4.65
```

Feedback?

PARTICIPATION ACTIVITY 3.9.1: Toll calculation.

For the given input, what is the final value of tollAmount?

1) 5:45

- 0.00
-

Correct

1.55
2.35

timeHour is assigned with 5. 5 < 6 is true, so the first branch executes, and tollAmount is assigned with 1.55.

2) 9:45

1.55
2.35
4.65

Correct

timeHour is assigned with 9. 9 < 6 is false, so the first branch does not execute. Then, 9 < 10 is evaluated, which is true. The second branch executes, and tollAmount is assigned with 4.65.

3) 10:00

1.55
2.35
4.65

Correct

timeHour is assigned with 10. 10 < 6 is false, and 10 < 10 is false, so the first two branches do not execute. Then, 10 < 18 is evaluated, which is true. Thus, the third branch executes, and tollAmount is assigned with 2.35.

4) 22:15

1.55
2.35

Correct

timeHour is assigned with 22, which is not less than 6, 10, or 18. Thus, the else branch executes and assigns tollAmount with 1.55.

Feedback?

Calculating toll based on time of day and day of week

A toll road often has a different toll schedule for weekends and holidays than for weekdays. The table below lists the toll schedule for weekends and holidays.

Table 3.9.2: Toll schedule for weekends and holidays.

Time (am/pm)	Time (24 hour)	Toll amount
Before 8:00 am	Before 8:00	1.55
8:00 am to 11:59 am	8:00 to 11:59	3.05
12:00 pm to 3:59 pm	12:00 to 15:59	3.45
4:00 pm to 6:59 pm	16:00 to 18:59	3.60
7:00 pm to 9:59 pm	19:00 to 21:59	3.05

10:00 pm and after	22:00 and after	1.55

Feedback?

The revised program below additionally gets the type of day from the user (0 for weekdays, and 1 for weekends or holidays). The program uses nested if-else statements to calculate the toll amount. The outer if-else checks if the today is a weekday or weekend/holiday. The nested if-else statements implement the respective toll schedules by determining the appropriate toll based on the hour of travel.

The program also uses if-else statements to output the time of travel using am/pm format instead of 24-hour format.

Figure 3.9.2: Calculating toll based on time of day and day of week.

```
#include <iostream>
#include <iomanip>
using namespace std;

int main() {
   int timeHour;      // Time of travel hour (24 hour format)
   int timeMinute;    // Time of travel minute
   int typeOfDay;     // 0 - weekday, 1 - weekend/holiday
   char inputColon;   // Used to read time format
   double tollAmount;

   cout << "Enter time of travel (HH:MM in 24 hour format): ";

   // Read an integer (hour), colon (char), and integer (minute)
   cin  >> timeHour >> inputColon >> timeMinute;

   cout << "Enter type of day (0 - weekday, 1 - weekend/holiday): ";
   cin >> typeOfDay;

   if (typeOfDay == 0) { // Weekday time and rates
                         // Determine toll based on hour of travel
      if (timeHour < 6) {         // Before 6:00 am
         tollAmount = 1.55;
      }
      else if (timeHour < 10) {   // 6 am to 9:59 am
         tollAmount = 4.65;
      }
      else if (timeHour < 18) {   // 10 am to 5:59 pm
         tollAmount = 2.35;
      }
      else {                      // 6 pm and after
         tollAmount = 1.55;
      }
   }
   else { // Weekend/holiday time and rates
          // Determine toll based on hour of travel
      if (timeHour < 8) {         // Before 8:00 am
         tollAmount = 1.55;
      }
      else if (timeHour < 12) {   // 8 am to 11:59 am
         tollAmount = 3.05;
      }
```

```
      else if (timeHour < 16) {    // 12 pm to 3:59 pm
         tollAmount = 3.45;
      }
      else if (timeHour < 19) {    // 4 pm to 6:5 9pm
         tollAmount = 3.60;
      }
      else if (timeHour < 22) {    // 7 pm to 9:59 pm
         tollAmount = 3.05;
      }
      else {                       // 10 pm and after
         tollAmount = 1.55;
      }
   }

   // Output toll using am/pm format
   cout << "Toll at ";

   // Output hour adjusting for am/pm format
   if (timeHour == 0) {
      cout << "12:";
   }
   else if (timeHour <= 12) {
      cout << timeHour << ":";
   }
   else {
      cout << timeHour - 12 << ":";
   }

   // Output minute with formatting (discussed elsewhere) to
   // print two digits for minutes.
   cout << setw(2) << setfill('0') << timeMinute;

   // Output am/pm
   if( timeHour < 12 ) {
      cout << " am";
   }
   else {
      cout << " pm";
   }

   cout << " is " << tollAmount << endl;

   return 0;
}
```

```
Enter time of travel (HH:MM in 24 hour format): 10:45
Enter type of day (0 - weekday, 1 - weekend/holiday): 1
Toll at 10:45 am is 3.05
```

Feedback?

PARTICIPATION ACTIVITY 3.9.2: If-else statements for calculating toll amount and formatting time.

1) The outer if-else statement checks the type of day, and the nested if-else statements check the hour of travel.

Correct

The outer if-else statements checks if typeOfDay is 0, in which case the nested if-else statements implement the weekday toll schedules. If typeDay is not 0, the else part's

- True
- False

nested if-else statement implements the toll schedule for weekends and holidays.

2) An alternative implementation that checks the hour of travel in an outer if-else statements and checks the type of day using nested if-else statements would have the same number of if statements.

- True
- False

Correct

Because the two toll schedules are not the same, this approach would have 10 branches in the outer if-else statement, and 2 branches in each nest if-else statement, for a total of 30 branches. The current implementations has 2 branches in the outer if-else statement, 4 branches in one of the nested if-else statements, and 6 branches in the other nested if-else statement, for a total of only 12 branches.

3) If timeHour is 0 and timeMinute is 30, the time will be output as: 0:30.

- True
- False

Correct

The if-else statements at the end of the program display the time using am/pm format. timeHours is 0, so the program prints 12 for the hour and 30 for the minutes, yielding 12:30.

Feedback?

Calculating toll with carpool discount

A toll road may have a discount for carpools, sometimes called high-occupancy vehicles (HOV). The following program uses if-else statement to adjust the toll amount based on the number of person in the vehicle. The carpool discount rules are:

- A carpool is 3 or more person per vehicle.
- The toll for carpools on weekdays between 6:00 am and 10:00 am is half the normal toll.
- Otherwise, the toll for carpools is 0 (as in free).

Figure 3.9.3: Calculating toll with carpool discount.

```
#include <iostream>
#include <iomanip>
using namespace std;

int main() {
   int timeHour;      // Time of travel hour (24 hour format)
   int timeMinute;    // Time of travel minute
   int typeOfDay;     // 0 - weekday, 1 - weekend/holiday
```

```
   int numPersons;    // Persons in vehicle
   char inputColon;   // Used to read time format
   double tollAmount;

   cout << "Enter time of travel (HH:MM in 24 hour format): ";

   // Read an integer (hour), colon (char), and integer (minute)
   cin  >> timeHour >> inputColon >> timeMinute;

   cout << "Enter type of day (0 - weekday, 1 - weekend/holiday): ";
   cin >> typeOfDay;

   cout << "Enter number of persons in vehicle: ";
   cin >> numPersons;

   if (typeOfDay == 0) { // Weekday time and rates
                         // Determine toll based on hour of travel
      if (timeHour < 6) {         // Before 6:00 am
         tollAmount = 1.55;
      }
      else if (timeHour < 10) {   // 6 am to 9:59 am
         tollAmount = 4.65;
      }
      else if (timeHour < 18) {   // 10 am to 5:59 pm
         tollAmount = 2.35;
      }
      else {                      // 6 pm and after
         tollAmount = 1.55;
      }
   }
   else { // Weekend/holiday time and rates
          // Determine toll based on hour of travel
      if (timeHour < 8) {         // Before 8:00 am
         tollAmount = 1.55;
      }
      else if (timeHour < 12) {   // 6 am to 11:59 am
         tollAmount = 3.05;
      }
      else if (timeHour < 16) {   // 12 pm to 3:59 pm
         tollAmount = 3.45;
      }
      else if (timeHour < 19) {   // 4 pm to 6:59 pm
         tollAmount = 3.60;
      }
      else if (timeHour < 22) {   // 7 pm to 9:59 pm
         tollAmount = 3.05;
      }
      else {                      // 10 pm and after
         tollAmount = 1.55;
      }
   }

   // Check for carpool rate (3 or persons) and update toll
   if (numPersons >= 3) {
      // If on a weekday between 6:00 am and 9:59 am, toll is half off
      if ((typeOfDay == 0) && (timeHour >= 6) && (timeHour < 10)) {
         tollAmount = tollAmount * 0.5;
      }
      // Otherwise, the toll is free
      else {
         tollAmount = 0.0;
      }
   }

   // Output toll using am/pm format
   cout << "Toll at ";

   // Output hour adjusting for am/pm format
   if (timeHour == 0) {
      cout << "12:";
```

```
   }
   else if (timeHour <= 12) {
      cout << timeHour << ":";
   }
   else {
      cout << timeHour - 12 << ":";
   }

   // Output minute with formatting (discussed elsewhere) to
   // print two digits for minutes.
   cout << setw(2) << setfill('0') << timeMinute;

   // Output am/pm
   if( timeHour < 12 ) {
      cout << " am";
   }
   else {
      cout << " pm";
   }

   cout << " is " << tollAmount << endl;

   return 0;
}
```

```
Enter time of travel (HH:MM in 24 hour format): 17:15
Enter type of day (0 - weekday, 1 - weekend/holiday): 0
Enter number of persons in vehicle: 3
Toll at 5:15 pm is 0
```

Feedback?

PARTICIPATION ACTIVITY 3.9.3: Toll calculation.

Match the final value of tollAmount to the timeHour, typeOfDay, and numPersons.

4.65	timeHour is 7, typeOfDay is 0, numPersons is 1 Based on the time and day, tollAmount is assigned with 4.65. numPersons is not greater than or equal to 3, so the if statement to adjust the toll for carpools does not executes.	**Correct**
	timeHour is 8, typeOfDay is 0, numPersons is 4 Based on the hour and type of day,	**Correct**

2.325

tollAmount is first assigned with 4.65. numPersons is >= 3, so the if statement to adjust the toll for carpools executes. typeOfDay is 0 and timeHour is both greater than 6 and less than 10, so tollAmount is assigned with 4.65 * 0.5, or 2.325.

0.0

timeHour is 18, typeOfDay is 1, numPersons is 3

Based on the hour and type of day, tollAmount is first assigned with 3.60. numPersons is >= 3, so the if statement to adjust the toll for carpools executes. typeOfDay is 1, so the else breach executes and assigns tollAmount with 0.0.

Correct

1.55

timeHour is 20, typeOfDay is 0, numPersons is 2

Based on the hour and type of day, tollAmount is assigned with 1.55. numPersons is not greater than or equal to 3, so the if statement to adjust the toll for carpools does not executes.

Correct

Reset

Feedback?