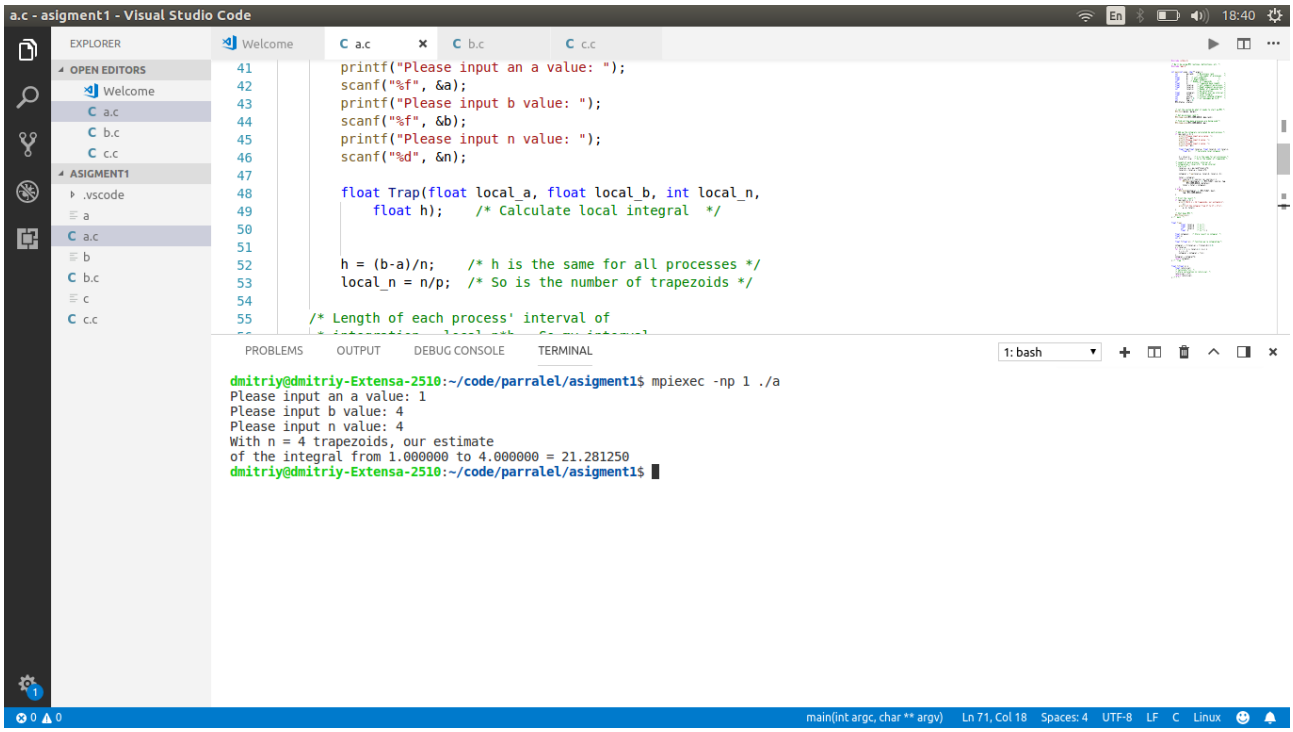
1.

```c
#include <stdio.h>

/* We'll be using MPI routines, definitions, etc. */
#include "mpi.h"


int main(int argc, char** argv) {
int my_rank; /* My process rank */
int p; /* The number of processes */
float a; /* Left endpoint */
float b; /* Right endpoint */
int n; /* Number of trapezoids */
float h; /* Trapezoid base length */
float local_a; /* Left endpoint my process */
float local_b; /* Right endpoint my process */
int local_n; /* Number of trapezoids for */
/* my calculation */
float integral; /* Integral over my interval */
float total; /* Total integral */
int source; /* Process sending integral */
int dest = 0; /* All messages go to 0 */
int tag = 0;
MPI_Status status;



/* Let the system do what it needs to start up MPI */
MPI_Init(&argc, &argv);

/* Get my process rank */
MPI_Comm_rank(MPI_COMM_WORLD, &my_rank);

/* Find out how many processes are being used */
MPI_Comm_size(MPI_COMM_WORLD, &p);



/* Add up the integrals calculated by each process */
if (my_rank == 0) {
printf("Please input an a value: ");
scanf("%f", &a);
printf("Please input b value: ");
scanf("%f", &b);
printf("Please input n value: ");
scanf("%d", &n);

float Trap(float local_a, float local_b, int local_n,
float h); /* Calculate local integral */
```

```
h = (b-a)/n; /* h is the same for all processes */
local_n = n/p; /* So is the number of trapezoids */

/* Length of each process' interval of
* integration = local_n*h. So my interval
* starts at: */
local_a = a + my_rank*local_n*h;
local_b = local_a + local_n*h;

integral = Trap(local_a, local_b, local_n, h);
total = integral;
for (source = 1; source < p; source++) {
MPI_Recv(&integral, 1, MPI_FLOAT, source, tag,
MPI_COMM_WORLD, &status);
total = total + integral;
}
} else {
MPI_Send(&integral, 1, MPI_FLOAT, dest,
tag, MPI_COMM_WORLD);
}

/* Print the result */
if (my_rank == 0) {
printf("With n = %d trapezoids, our estimate\n",
n);
printf("of the integral from %f to %f = %f\n",
a, b, total);
}

/* Shut down MPI */
MPI_Finalize();
} /* main */


float Trap(
float local_a /* in */,
float local_b /* in */,
int local_n /* in */,
float h /* in */) {

float integral; /* Store result in integral */
float x;
int i;

float f(float x); /* function we're integrating */

integral = (f(local_a) + f(local_b))/2.0;
x = local_a;
for (i = 1; i <= local_n-1; i++) {
x = x + h;
integral = integral + f(x);
```

```
}
integral = integral*h;
return integral;
} /* Trap */


float f(float x) {
float return_val;
/* Calculate f(x). */
/* Store calculation in return_val. */
return_val = x*x;
return return_val;
} /* f */
```

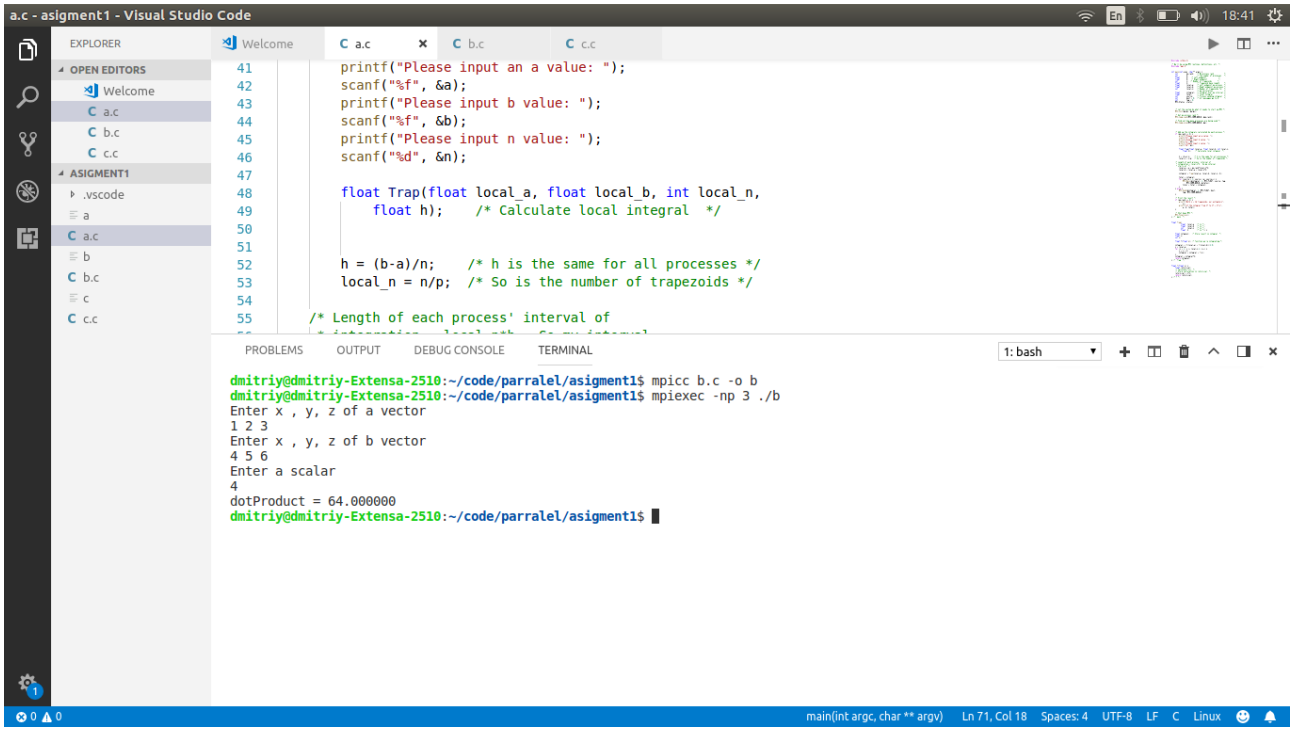


2.

```
#include <stdio.h>

/* We'll be using MPI routines, definitions, etc. */
#include "mpi.h"

double dotProduct(double *a, double *b, int n) {
int i;
double prod = 0.0;
for (i = 0; i < n; i++) {
prod += a[i]*b[i];
}
return prod;
}
```

```
int main(int argc, char** argv) {
int my_rank;
int p;
double prod;
const int root=0;
int number = 3,a[3],b[3],i=0,j = 0,n = 3,loc_n;
int scalar;
//Number of scanfs
// a[0] = 1;
// a[1] = 2;
// a[2] = 3;
// b[0] = 4;
// b[1] = 5;
// b[2] = 6;
/* Let the system do what it needs to start up MPI */
MPI_Init(&argc, &argv);

/* Get my process rank */
MPI_Comm_rank(MPI_COMM_WORLD, &my_rank);

/* Find out how many processes are being used */
MPI_Comm_size(MPI_COMM_WORLD, &p);

if (my_rank == 0)
{
printf("Enter x , y, z of a vector \n");
while(i<number)
{
scanf("%d",&a[i]);
i++;
}
printf("Enter x , y, z of b vector\n");
while(j<number)
{
scanf("%d",&b[j]);
j++;
}
printf("Enter a scalar \n");
scanf("%d" ,&scalar);

// MPI_Scatter(&a,3,MPI_INT,&a,3,MPI_INT,my_rank,MPI_COMM_WORLD);
// MPI_Scatter(&b,3,MPI_INT,&b,3,MPI_INT,my_rank,MPI_COMM_WORLD);

}
MPI_Bcast(&a, 3, MPI_INT, root, MPI_COMM_WORLD);
MPI_Bcast(&b, 3, MPI_INT, root, MPI_COMM_WORLD);
// else{
loc_n = n/p;
double local_a[loc_n];
double local_b[loc_n];
for(i = 0; i < loc_n; i++) {
```

```
local_a[i] = scalar * a[i + my_rank * loc_n];
local_b[i] = scalar * b[i + my_rank * loc_n];
}
double local_prod;
local_prod = dotProduct(local_a,local_b,loc_n);
//printf("%f \n",local_prod);
MPI_Reduce(&local_prod, &prod, 1, MPI_DOUBLE, MPI_SUM, 0, MPI_COMM_WORLD);
//MPI_Reduce_scatter(&local_prod, &prod, &root, MPI_DOUBLE, MPI_SUM,
MPI_COMM_WORLD);
// float global_sum;
// MPI_Allreduce(&local_prod, &prod, 1, MPI_FLOAT, MPI_SUM,
// MPI_COMM_WORLD);
// }
if (my_rank == 0) {
printf("dotProduct = %f\n", prod);
}
MPI_Finalize();
return 0;

} /* main */
```



3.

```c
#include <stdio.h>
#include <mpi.h>

int main(int argc, char** argv) {

MPI_Init(&argc, &argv);

   int rank, size;
   MPI_Comm_rank(MPI_COMM_WORLD, &rank);
   MPI_Comm_size(MPI_COMM_WORLD, &size);

   int number = rank + 1;
int summ = 0;
int diff = size / 2;
int total = 0;
MPI_Allreduce(&number, &total, 1, MPI_INT,
MPI_SUM, MPI_COMM_WORLD);
if(rank == 0){
    printf("%d\n", total);
}

   MPI_Finalize();

   return 0;
}
```