Walchand College of Engineering, Sangli
Department of Computer Science and Engineering
Final Year: High Performance Computing Lab 2022-23 Sem I
Class: Final Year (Computer Science and Engineering)
Year: 2022-23
Course: High Performance Computing Lab

Practical No. 9

PRN: **2019BTECS00035**
Title: **CUDA Programming**

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1. Implement Vector-Vector addition using CUDA C. State and justify the speedup using different size of threads and blocks.

Link:
https://github.com/Dnyaneshwar-dev/HPC-Lab-Sem1/blob/main/Assignment%209/vector_vector_add.cu

<<<1,1>>>

```
CUDA API Statistics:

 Time(%)  Total Time (ns)  Num Calls    Average      Minimum     Maximum           Name
 -------  ---------------  ---------  ------------  ----------  ----------  --------------------
    90.9       2554324129          1  2554324129.0  2554324129  2554324129  cudaDeviceSynchronize
     8.7        245935747          3    81978582.3       17683   245874732  cudaMallocManaged
     0.4         11084859          3     3694953.0     3654372     3769441  cudaFree
     0.0            35339          1       35339.0       35339       35339  cudaLaunchKernel


CUDA Kernel Statistics:

 Time(%)  Total Time (ns)  Instances    Average      Minimum     Maximum                      Name
 -------  ---------------  ---------  ------------  ----------  ----------  ----------------------------------------
----
   100.0       2554312801          1  2554312801.0  2554312801  2554312801  addVectorsInto(float*, float*, float*,
int)
```

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```
CUDA API Statistics:

 Time(%)  Total Time (ns)  Num Calls    Average      Minimum     Maximum           Name
 -------  ---------------  ---------  ------------  ----------  ----------  --------------------
    80.4       1186753450          1  1186753450.0  1186753450  1186753450  cudaDeviceSynchronize
    18.8        277383284          3    92461094.7       37380   277258201  cudaMallocManaged
     0.7         11045454          3     3681818.0     3636430     3755256  cudaFree
     0.0           126458          1      126458.0      126458      126458  cudaLaunchKernel


CUDA Kernel Statistics:

 Time(%)  Total Time (ns)  Instances    Average      Minimum     Maximum                       Name
 -------  ---------------  ---------  ------------  ----------  ----------  ----------------------------------------
----
   100.0       1186815460          1  1186815460.0  1186815460  1186815460  addVectorsInto(float*, float*, float*,
int)
```

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```
CUDA API Statistics:

 Time(%)  Total Time (ns)  Num Calls    Average     Minimum    Maximum          Name
 -------  ---------------  ---------  ------------  ---------  ---------  --------------------
    73.6        858434778          1  858434778.0  858434778  858434778  cudaDeviceSynchronize
    25.4        296207818          3   98735939.3      23956  296128750  cudaMallocManaged
     1.0         11078004          3    3692668.0    3643346    3786344  cudaFree
     0.0            33956          1      33956.0      33956      33956  cudaLaunchKernel


CUDA Kernel Statistics:

 Time(%)  Total Time (ns)  Instances    Average     Minimum    Maximum                      Name
 -------  ---------------  ---------  ------------  ---------  ---------  ----------------------------------------
-
   100.0        858423656          1  858423656.0  858423656  858423656  addVectorsInto(float*, float*, float*, in
t)
```

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```
CUDA API Statistics:

 Time(%)  Total Time (ns)  Num Calls    Average     Minimum    Maximum          Name
 -------  ---------------  ---------  ------------  ---------  ---------  --------------------
    66.8        509056580          1  509056580.0  509056580  509056580  cudaDeviceSynchronize
    31.7        241344771          3   80448257.0      21366  241280309  cudaMallocManaged
     1.5         11359506          3    3786502.0    3657386    4001366  cudaFree
     0.0            32914          1      32914.0      32914      32914  cudaLaunchKernel


CUDA Kernel Statistics:

 Time(%)  Total Time (ns)  Instances    Average     Minimum    Maximum                      Name
 -------  ---------------  ---------  ------------  ---------  ---------  ----------------------------------------
-
   100.0        509042775          1  509042775.0  509042775  509042775  addVectorsInto(float*, float*, float*, in
t)
```

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```
CUDA API Statistics:

 Time(%)  Total Time (ns)  Num Calls    Average     Minimum    Maximum          Name
 -------  ---------------  ---------  -----------  ---------  ---------  --------------------
    66.8        509056580          1  509056580.0  509056580  509056580  cudaDeviceSynchronize
    31.7        241344771          3   80448257.0      21366  241280309  cudaMallocManaged
     1.5         11359506          3    3786502.0    3657386    4001366  cudaFree
     0.0            32914          1      32914.0      32914      32914  cudaLaunchKernel


CUDA Kernel Statistics:

 Time(%)  Total Time (ns)  Instances    Average     Minimum    Maximum                      Name
 -------  ---------------  ---------  -----------  ---------  ---------  ----------------------------------------
-
   100.0        509042775          1  509042775.0  509042775  509042775  addVectorsInto(float*, float*, float*, in
t)
```

<<<4,32>>>

```
CUDA API Statistics:

 Time(%)  Total Time (ns)  Num Calls    Average     Minimum    Maximum          Name
 -------  ---------------  ---------  -----------  ---------  ---------  --------------------
    61.3        347184059          3  115728019.7      35520  347059687  cudaMallocManaged
    35.4        200506725          1  200506725.0  200506725  200506725  cudaDeviceSynchronize
     3.3         18452278          3    6150759.3    6117886    6209487  cudaFree
     0.0           149897          1     149897.0     149897     149897  cudaLaunchKernel


CUDA Kernel Statistics:

 Time(%)  Total Time (ns)  Instances    Average     Minimum    Maximum                      Name
 -------  ---------------  ---------  -----------  ---------  ---------  ----------------------------------------
-
   100.0        200586402          1  200586402.0  200586402  200586402  addVectorsInto(float*, float*, float*, in
t)
```

<<<8,32>>>

```
CUDA API Statistics:

 Time(%)  Total Time (ns)  Num Calls    Average     Minimum    Maximum          Name
 -------  ---------------  ---------  -----------  ---------  ---------  --------------------
    64.4        253212370          3   84404123.3      17962  253152365  cudaMallocManaged
    30.9        121653113          1  121653113.0  121653113  121653113  cudaDeviceSynchronize
     4.7         18512697          3    6170899.0    6107213    6223474  cudaFree
     0.0            34017          1      34017.0      34017      34017  cudaLaunchKernel


CUDA Kernel Statistics:

 Time(%)  Total Time (ns)  Instances    Average     Minimum    Maximum                      Name
 -------  ---------------  ---------  -----------  ---------  ---------  ----------------------------------------
-
   100.0        121642163          1  121642163.0  121642163  121642163  addVectorsInto(float*, float*, float*, in
t)
```

2. Implement N-Body Simulator using CUDA C. State and justify the speedup using different size of threads and blocks.

Link:

https://github.com/Dnyaneshwar-dev/HPC-Lab-Sem1/blob/main/Assignment%209/n_body.cu

<<<1,1>>>>

```
CUDA API Statistics:

 Time(%)  Total Time (ns)  Num Calls    Average      Minimum     Maximum            Name
 -------  ---------------  ---------  ------------  ----------  ----------  --------------------
    87.8      10929649903         10  1092964990.3  1076044133  1241281218  cudaDeviceSynchronize
    12.2       1516692455          1  1516692455.0  1516692455  1516692455  cudaMallocManaged
     0.0           629399          1      629399.0      629399      629399  cudaFree
     0.0           423858         10       42385.8       38046       55840  cudaLaunchKernel


CUDA Kernel Statistics:

 Time(%)  Total Time (ns)  Instances    Average      Minimum     Maximum               Name
 -------  ---------------  ---------  ------------  ----------  ----------  ----------------------------
   100.0      10929546123         10  1092954612.3  1076034573  1241267682  bodyForce(Body*, float, int)
```

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```
CUDA API Statistics:

 Time(%)  Total Time (ns)  Num Calls    Average     Minimum    Maximum           Name
 -------  ---------------  ---------  -----------  ---------  ---------  --------------------
    82.4       1491777026         10  149177702.6  134428014  256536670  cudaDeviceSynchronize
    17.6        318586945          1  318586945.0  318586945  318586945  cudaMallocManaged
     0.0           419497         10      41949.7      36900      50946  cudaLaunchKernel
     0.0           221297          1     221297.0     221297     221297  cudaFree


CUDA Kernel Statistics:

 Time(%)  Total Time (ns)  Instances    Average     Minimum    Maximum               Name
 -------  ---------------  ---------  -----------  ---------  ---------  ----------------------------
   100.0       1491662550         10  149166255.0  134413967  256522198  bodyForce(Body*, float, int)
```

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```
CUDA API Statistics:

 Time(%)  Total Time (ns)  Num Calls    Average     Minimum    Maximum           Name
 -------  ---------------  ---------  -----------  ---------  ---------  --------------------
    64.5        475152338         10   47515233.8   33871459   83956236  cudaDeviceSynchronize
    35.4        260501890          1  260501890.0  260501890  260501890  cudaMallocManaged
     0.1           433042         10      43304.2      37221      57451  cudaLaunchKernel
     0.0           207387          1     207387.0     207387     207387  cudaFree


CUDA Kernel Statistics:

 Time(%)  Total Time (ns)  Instances   Average    Minimum   Maximum              Name
 -------  ---------------  ---------  ----------  --------  --------  ---------------------------
   100.0        475047121         10  47504712.1  33860616  83944746  bodyForce(Body*, float, int)


CUDA Memory Operation Statistics (by time):
```

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```
CUDA API Statistics:

 Time(%)  Total Time (ns)  Num Calls    Average     Minimum    Maximum           Name
 -------  ---------------  ---------  -----------  ---------  ---------  --------------------
    84.6       1493692277         10  149369227.7  135546052  260459803  cudaDeviceSynchronize
    15.3        270486666          1  270486666.0  270486666  270486666  cudaMallocManaged
     0.0           399486         10      39948.6      26675      85787  cudaLaunchKernel
     0.0           218143          1     218143.0     218143     218143  cudaFree


CUDA Kernel Statistics:

 Time(%)  Total Time (ns)  Instances    Average     Minimum    Maximum              Name
 -------  ---------------  ---------  -----------  ---------  ---------  ---------------------------
   100.0       1493592090         10  149359209.0  135533758  260451176  bodyForce(Body*, float, int)


CUDA Memory Operation Statistics (by time):
```

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```
CUDA API Statistics:

 Time(%)  Total Time (ns)  Num Calls    Average     Minimum    Maximum           Name
 -------  ---------------  ---------  -----------  ---------  ---------  --------------------
    51.8        299623083         10   29962308.3   20722449   42275634  cudaDeviceSynchronize
    48.1        278583613          1  278583613.0  278583613  278583613  cudaMallocManaged
     0.1           357061         10      35706.1      22342      61773  cudaLaunchKernel
     0.0           149090          1     149090.0     149090     149090  cudaFree


CUDA Kernel Statistics:

 Time(%)  Total Time (ns)  Instances   Average    Minimum   Maximum              Name
 -------  ---------------  ---------  ----------  --------  --------  ---------------------------
   100.0        299544675         10  29954467.5  20720835  42264268  bodyForce(Body*, float, int)


CUDA Memory Operation Statistics (by time):
```

<<<8,32>>>

```
CUDA API Statistics:

 Time(%)  Total Time (ns)  Num Calls    Average     Minimum    Maximum           Name
 -------  ---------------  ---------  -----------  ---------  ---------  --------------------
    76.6        348379716          1  348379716.0  348379716  348379716  cudaMallocManaged
    23.3        106141803         10   10614180.3   10538309   10898919  cudaDeviceSynchronize
     0.1           344828         10      34482.8      27243      48807  cudaLaunchKernel
     0.0           147002          1     147002.0     147002     147002  cudaFree


CUDA Kernel Statistics:

 Time(%)  Total Time (ns)  Instances   Average    Minimum   Maximum              Name
 -------  ---------------  ---------  ----------  --------  --------  ----------------------------
   100.0        106097714         10  10609771.4  10564862  10886163  bodyForce(Body*, float, int)
```

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```
CUDA API Statistics:

 Time(%)  Total Time (ns)  Num Calls    Average     Minimum    Maximum           Name
 -------  ---------------  ---------  -----------  ---------  ---------  --------------------
    63.7        482996529         10   48299652.9   34254934   85043690  cudaDeviceSynchronize
    36.2        274576766          1  274576766.0  274576766  274576766  cudaMallocManaged
     0.1           540409         10      54040.9      36551      94474  cudaLaunchKernel
     0.0           226592          1     226592.0     226592     226592  cudaFree


CUDA Kernel Statistics:

 Time(%)  Total Time (ns)  Instances   Average    Minimum   Maximum              Name
 -------  ---------------  ---------  ----------  --------  --------  ----------------------------
   100.0        481792365         10  48179236.5  34245868  84144637  bodyForce(Body*, float, int)
```

<<<32,8>>>

```
CUDA API Statistics:

 Time(%)  Total Time (ns)  Num Calls    Average     Minimum    Maximum           Name
 -------  ---------------  ---------  -----------  ---------  ---------  --------------------
    70.7        257618298          1  257618298.0  257618298  257618298  cudaMallocManaged
    29.1        106210181         10   10621018.1   10244156   10963059  cudaDeviceSynchronize
     0.1           416055         10      41605.5      32463      49771  cudaLaunchKernel
     0.1           245095          1     245095.0     245095     245095  cudaFree


CUDA Kernel Statistics:

 Time(%)  Total Time (ns)  Instances   Average    Minimum   Maximum              Name
 -------  ---------------  ---------  ----------  --------  --------  ----------------------------
   100.0        106103392         10  10610339.2  10230412  10947990  bodyForce(Body*, float, int)
```

<<<32,32>>>

```
CUDA API Statistics:

 Time(%)  Total Time (ns)  Num Calls    Average     Minimum    Maximum           Name
 -------  ---------------  ---------  -----------  ---------  ---------  --------------------
    93.9        458871591          1  458871591.0  458871591  458871591  cudaMallocManaged
     5.9         29008838         10    2900883.8    2809835    3179646  cudaDeviceSynchronize
     0.1           336635          1     336635.0     336635     336635  cudaFree
     0.1           270057         10      27005.7      13976      86669  cudaLaunchKernel


CUDA Kernel Statistics:

 Time(%)  Total Time (ns)  Instances   Average   Minimum  Maximum              Name
 -------  ---------------  ---------  ---------  -------  -------  ----------------------------
   100.0         28969181         10  2896918.1  2797197  3177089  bodyForce(Body*, float, int)
```