1. Create an m x n matrix with replicate(m, rnorm(n)) with m=10 column vectors of n=10 elements each, constructed with rnorm(n), which creates random normal numbers.
   - Then we transform it into a dataframe (thus 10 observations of 10 variables) and perform an algebraic operation on each element using a nested for loop: at each iteration, every element referred by the two indexes is incremented by a sinusoidal function, compare the vectorized and non-vectorized form of creating the solution and report the system time differences.

#vectorized form
set.seed(42)
#create matrix
mat_1 <- replicate(10, rnorm(10))
#transform into data frame
df_1 = data.frame(mat_1)
df_1 <- df_1 + 10*sin(0.75*pi)
df_1

```
> df_1
          X1       X2       X3       X4       X5       X6       X7       X8
X9       X10
1   8.442026 8.375937 6.764429 7.526518 7.277066 7.392993 6.703833 6.027949 8.58
3775 8.463184
2   6.506370 9.357713 5.289759 7.775905 6.710011 6.287229 7.256298 6.980881 7.32
8989 6.594894
3   7.434196 5.682207 6.899150 8.106171 7.829231 8.646795 7.652892 7.694586 7.15
9508 7.721416
4   7.703930 6.792279 8.285743 6.462141 6.344363 7.713967 8.470805 6.117544 6.95
0171 8.462178
5   7.475336 6.937746 8.966261 7.576023 5.702787 7.160828 6.343776 6.528239 5.87
6739 5.960279
6   6.964943 7.707018 6.640599 5.354059 7.503886 7.347619 8.373610 7.652064 7.68
3065 6.210275
7   8.582590 6.786815 6.813798 6.286609 6.259675 7.750357 7.406916 7.839247 6.85
3928 5.939329
8   6.976409 4.414612 5.307905 6.220160 8.515169 7.160901 8.109574 7.534835 6.88
8311 5.611854
9   9.089492 4.630601 7.531165 4.656860 6.639622 4.077978 7.991796 6.185292 8.00
4414 7.151050
10 7.008354 8.391181 6.431073 7.107190 7.726716 7.355951 7.791946 5.971287 7.89
2841 7.724272
```

#non-vectorized form
set.seed(42)
#create Matrix
mat_2 <- replicate(10, rnorm(10))
#transform into dataframe
df_2 = data.frame(mat_2)
for(i in 1:10){
  for(j in 1:10){
    df_1[i,j] <- df_1[i,j] + 10*sin(0.75*pi)
    print(df_1)
  }
}

#time difference

```
system.time(
  df_1 <- df_1 + 10*sin(0.75*pi)
)
```

```
user   system elapsed
    0        0        0
```

```
system.time(
  for(i in 1:10){
    for(j in 1:10){
      df_1[i,j] <- df_1[i,j] + 10*sin(0.75*pi)
      print(df_1)
    }
  }
)
```

```
user   system elapsed
 1.04     0.02    1.02
```