Candidate number: 22853
Date: 29/11/2019

PH20105 Experimental Physics & Computing 2: MATLAB assignment

# Part 1

### Question 1.

```
x = 20 - (3 - 7*exp(2 + 1i*pi*cos(pi/3)));
```

Output: 17.0000000000000 + 51.7233926925146i

### Question 2.

```
v1 = transpose((1:10));
```

Output: [1;2;3;4;5;6;7;8;9;10]

### Question 3.

```
imag(x + ((2 + 1i)*v1(5)));
```

Output: 56.723392692514550

### Question 4.

```
v2 = v1.^2;
```

Output: [1;4;9;16;25;36;49;64;81;100]

### Question 5.

```
dot(v1, v2);
```

Output: 3025

### Question 6.

```
Matrix1 = randi([2 10], [15,10]);
```

Output: 15x10 matrix

### Question 7.

```
det(Matrix1(1:10,1:10));
```

Output: random, ~ order 10^7

### Question 8.

```
sum(sum(Matrix1>5));
```

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Output: random ~ 80

**Question 9.**

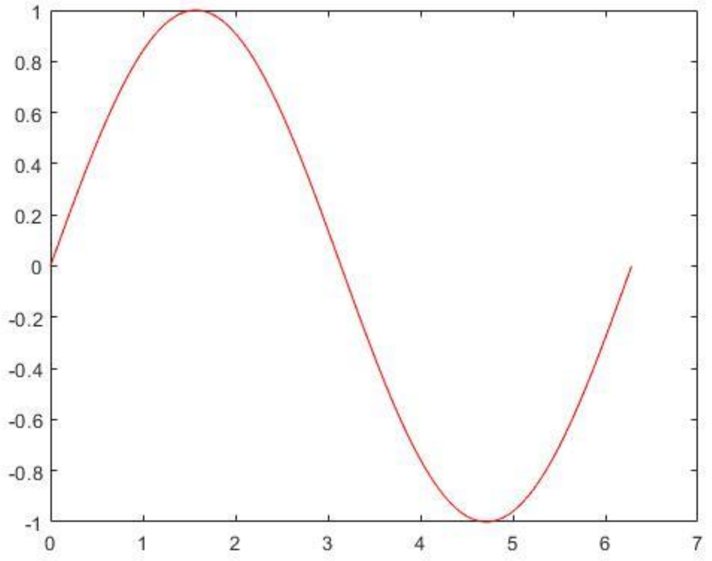
```
max(Matrix1(3,:));
```

Output: random, usually 10

**Question 10.**

```
plot(linspace(0,2*pi, 200), sin(linspace(0,2*pi, 200)), 'r');
```

Output:




**Question 11.**

```
Matrix2 = plus(Matrix1(1:10, 1:10), transpose(Matrix1(1:10, 1:10)));
```

Output: 10x10 matrix

**Question 12.**

```
max(eig(Matrix2));
```

Output: random

**Question 13.**

```
trapz(2:0.0001:5, (1+(2:0.0001:5)).^2);
```

Output: 63.000000005000004, ~= 63

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# Part 2

### Question 1.

```
k = 8.99 * 10^9; % N·m^2·C^?2 (Coulomb constant)
% Creates 3D grid from the vector argument
[x,y,z] = meshgrid(-4:0.1:4);
% Superposition of Coulomb potentials using element-wise operations
Vexact = k * ((x.^2 + (y-1).^2 + z.^2).^-1 - (x.^2 + (y+1).^2 + z.^2).^-1);
```

### Question 2.

```
% Define an identical grid with elements that are 10 times larger to allow
% for integer search for -8 instead of for -0.8
G = -40:1:40;
find(G == 10); % returns 51
find(G == -8); % returns 33
find(G == 35); % returns 76
```

The locations were found to be 1 at index 51, -0.8 at index 33 and 3.5 at index 76.

### Question 3.

```
% Looks for where Vexact is tending to infinity or is 'not a number'
infsearch = find(isnan(Vexact)| (Vexact)==Inf | Vexact == -Inf);

% Finds the index in x, y & z where these occur
xindex = find(-4:0.1:4 == x(infsearch(1))); % returns 41
yindex = find(-4:0.1:4 == y(infsearch(1))); % returns 31
yindex2 = find(-4:0.1:4 == y(infsearch(2))); % returns 51
zindex = find(-4:0.1:4 == z(infsearch(1))); % returns 41
```

The Inf and Nan elements were found at x-index = 41 which corresponds to where x = 0, at y-index = 31 where y = -1, at y-index = 51 where y = 1 and z-index = 41 where x = 0. These are physical based on the behaviour of the exact equation which is asymptotic at the location of the point charges (where y = ± 1 and where x = 0 and z = 0). Points: (0,0, ±1).

### Question 4.

```
% Create new 3D grid with different dimensions
[x,y,z] = meshgrid(-4.05:0.1:4.05, -4.05:0.1:4.05, -4:0.1:4);
% Recalculate the potential for the new grid
Vexact2 = k * (((x).^2 + (y-1).^2 + z.^2).^-1 - ((x).^2 + (y+1).^2 + z.^2).^-
1);
```

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### Question 5.

```
% for r >> d
% V = kqdcos(theta)/r^2
% d is seperation between dipoles = 2
% q is absolute sign of each pole = 1
% r is vector from center of dipole to point
% theta is angle between y axis and point

d = 2;

% Using approximation for cos(theta) such that cos(theta) ~= y / r
% V = kqd * y/r^3 = kqd * y.(x^2 + y^2 + z^2)^3/2
Vapprox = k*d*y./(x.^2 + y.^2 + z.^2).^1.5;
```

### Question 6.

```
Vdiff = Vexact2 - Vapprox;

% plot the the difference in potential at z = 0 which is located at index 41
figure('name', 'Vdiff');
surf(x(:, :, 41),y(:,:,41), Vdiff(:,:,41));
zlabel('Vdiff');
xlabel('x');
ylabel('y');
```

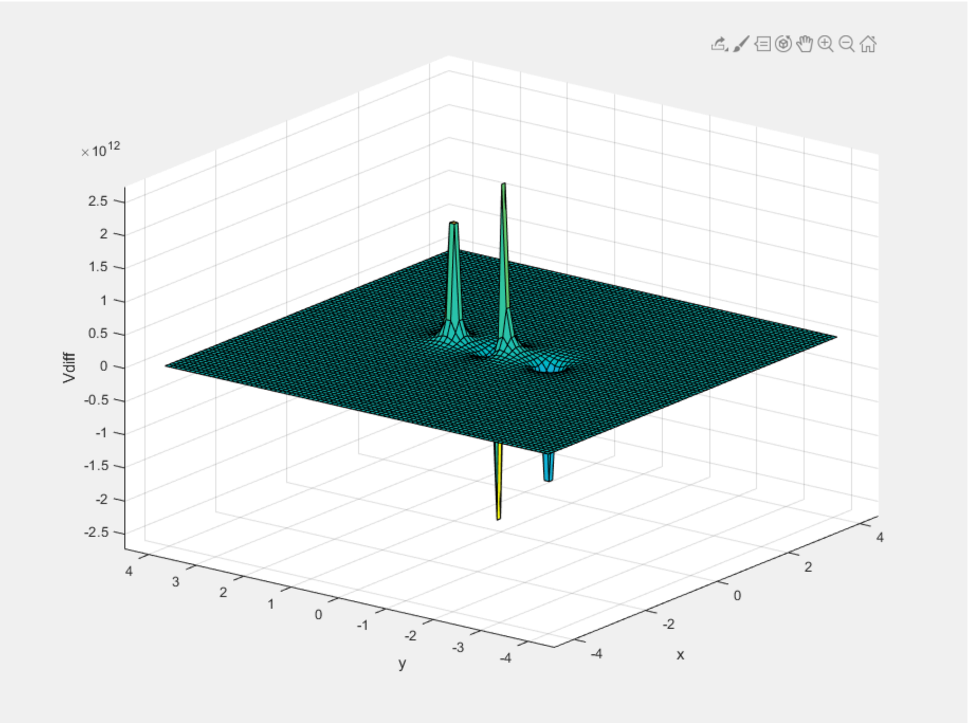


**Figure 1 –** A graph of Vdiff (the difference between Vexact2 and Vapprox) at z = 0 at points in the x,y plane.

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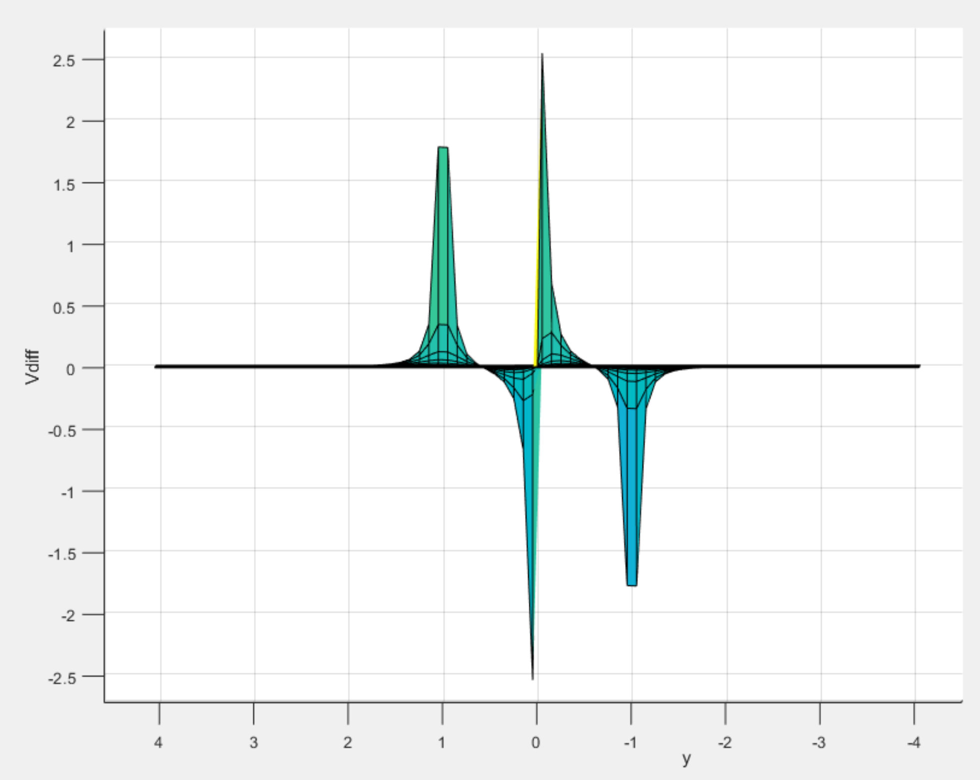


**Figure 2 –** This graph is the same as Figure 1 but from a side-view such that it shows Vdiff against y.

Fig.1 and Fig.2 show the difference between Vexact2 and Vapprox. The clear features are the furthest peaks outward. These are due to y approaching -1 and +1 which is where the potential tends to infinity as the distance from the charges at these points approaches zero (division by zero causes asymptotic behaviour. The other important features are the pair of central peaks which result from the dipole approximation have an r^2 term in the denominator. Therefore, as r tends to zero the potential tends to positive infinity, the y term in the numerator makes the potential sign dependent on y.

Question 7.

```
[Ex, Ey, Ez] = gradient(-Vexact2);
```

Question 8.

```
% Plot the potential using the quiver command which uses arrows to display
% the vectors.
figure('name', 'Field visualization');
quiver(x, y, Ex, Ey, 'linewidth', 2);
% Sets the range for the diagram's x and y axis
axis([-1.55 1.55 -1.55 1.55]);
xlabel('x');
ylabel('y');
```

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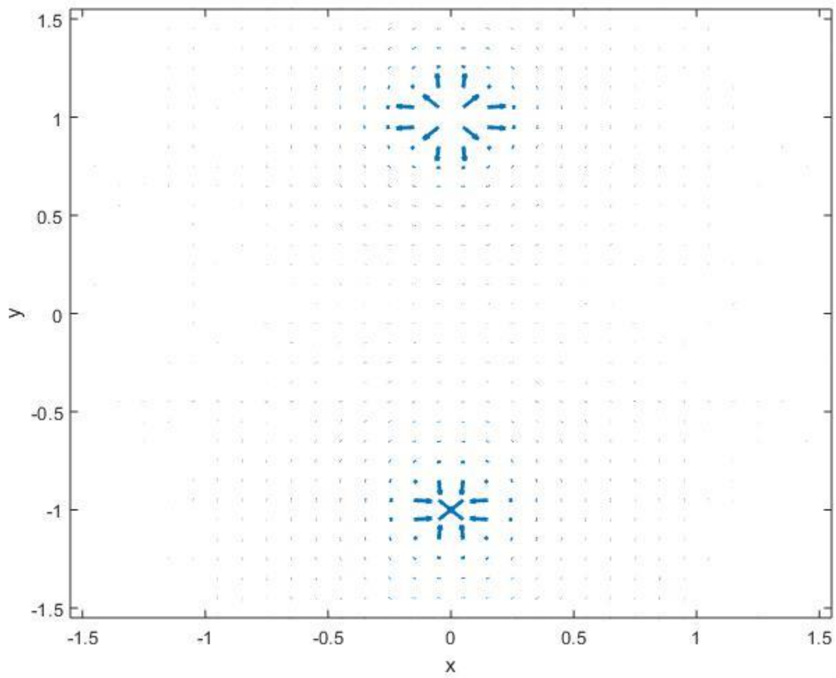


**Figure 3 - a visualization of the electric field around two point charges.**

Figure 3 shows the positive charge at (0,1) acting as a source of positive charge (outwards pointing arrows) and the negative charge at (0,-1) acting as a sink (inwards pointing arrows). The size of the arrows indicates the strength of the field in that region.