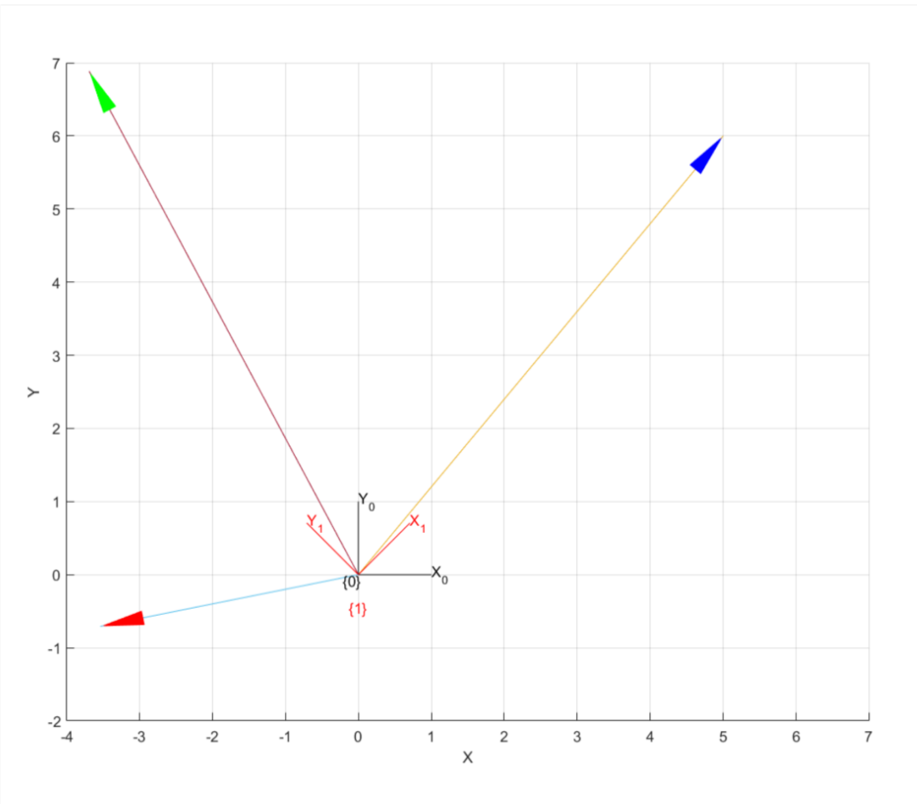
Answer Sheet

Index No: 210503H

1. MATLAB code for 3.1 ~ 3.5.

```
% 2d coordinate frame
figure;
trplot2(eye(3), 'frame', '0', 'color', 'black');
hold on;
axis([-4 7 -2 7]); % range
grid on;

% 3.1 point [5 6] in fram {0}
p_in_0 = [5; 6];
plot_arrow([0 0], p_in_0, 'b');  % blue arrow for p

% 3.2 rotate frame {0} counter clockwise by 45deg
R_1_in_0 = rot2(deg2rad(45));
T1 = [R_1_in_0 [0; 0]; 0 0 1];
tranimate2(eye(3), T1, 'frame', '1', 'color', 'red');

p_in_1 = R_1_in_0* p_in_0;  % coordinates of p in frame {1}
disp('coordinates of p in frame {1}:');
disp(p_in_1);

% q [-3 2] in fram {1}
q = R_1_in_0 * [-3; 2];
plot_arrow([0 0], q, 'r');  % red arrow from origin to point q

R_68 = rot2(deg2rad(68));  % rotation matrix for 68 degrees
r = R_68 * p_in_0;  % r
plot_arrow([0 0], r', 'g'); % green arrow from origin to point r
```

2. Final output MATLAB figure for the operations in 3.1 ~ 3.5.



3. p^1 for 3.3:

```
coordinates of p in frame {1}:
   -0.7071
    7.7782
```

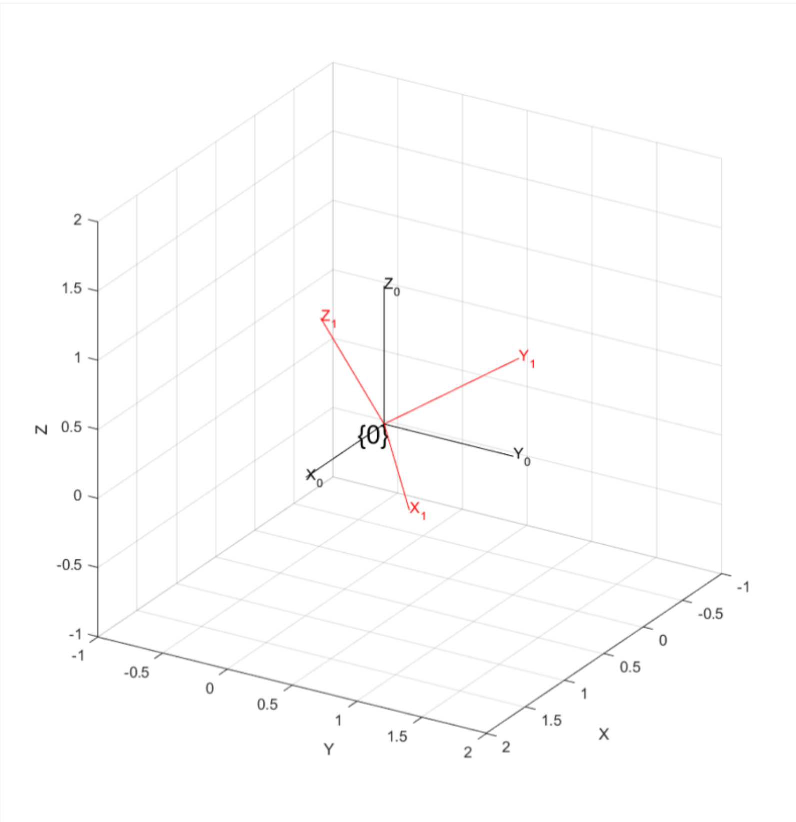
4. R_1^0 for 3.7.

```
R_1_in_0:
    0.7424   -0.4644    0.4828
    0.5198    0.8540    0.0221
   -0.4226    0.2346    0.8754
```

5. MATLAB code for 3.6 ~ 3.9.

```
% 3.6 visualize 3d coord frame 0
figure;
trplot(eye(3), 'frame', '0', 'color', 'black');
hold on;
axis([-1 2 -1 2 -1 2]);  % limit plot area for 3d
grid on;
view(3);

% 3.7 obtain another 3d coord frame {1}
R_x_15 = rotx(deg2rad(15));
R_y_25 = roty(deg2rad(25));
R_z_35 = rotz(deg2rad(35));

R_1_in_0 = R_z_35 * R_y_25 * R_x_15;  % combined rotation matrix
% sequentially animate to frame {1}
tranimate(eye(3), R_x_15, 'frame', '1', 'color', 'red', 'cleanup');
tranimate(R_x_15, R_x_15 * R_y_25, 'frame', '1', 'color', 'blue', 'cleanup');
tranimate(R_x_15 * R_y_25, R_x_15 * R_y_25* R_z_35, 'frame', '1', 'color', 'red');

disp('R_1_in_0:');
disp(R_1_in_0);

%3.9
R = [0.8138 0.0400 0.5798;
     0.2962 0.8298 -0.4730;
    -0.5000 0.5567 0.6634];

[rpy_angles_R] = tr2rpy(R, 'zyx', 'deg');
fprintf('Roll: %.5f, Pitch: %.5f, Yaw: %.5f\n', rpy_angles_R(1), rpy_angles_R(2), rpy_angles_R(3));
```

6. Final output MATLAB figure for the operations in 3.6 ~ 3.9.



7. Default roll-pitch-yaw angle definition for the toolbox.

   The default RPY convention in the Robotics Toolbox is ZYX

8. For 3.9,
   ψ: 40.0021 θ: 29.9999 φ: 20.0001