Move

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	Level	Completed
	Beginner	9
	Intermediate	8
	Advanced	1
	Expert	0

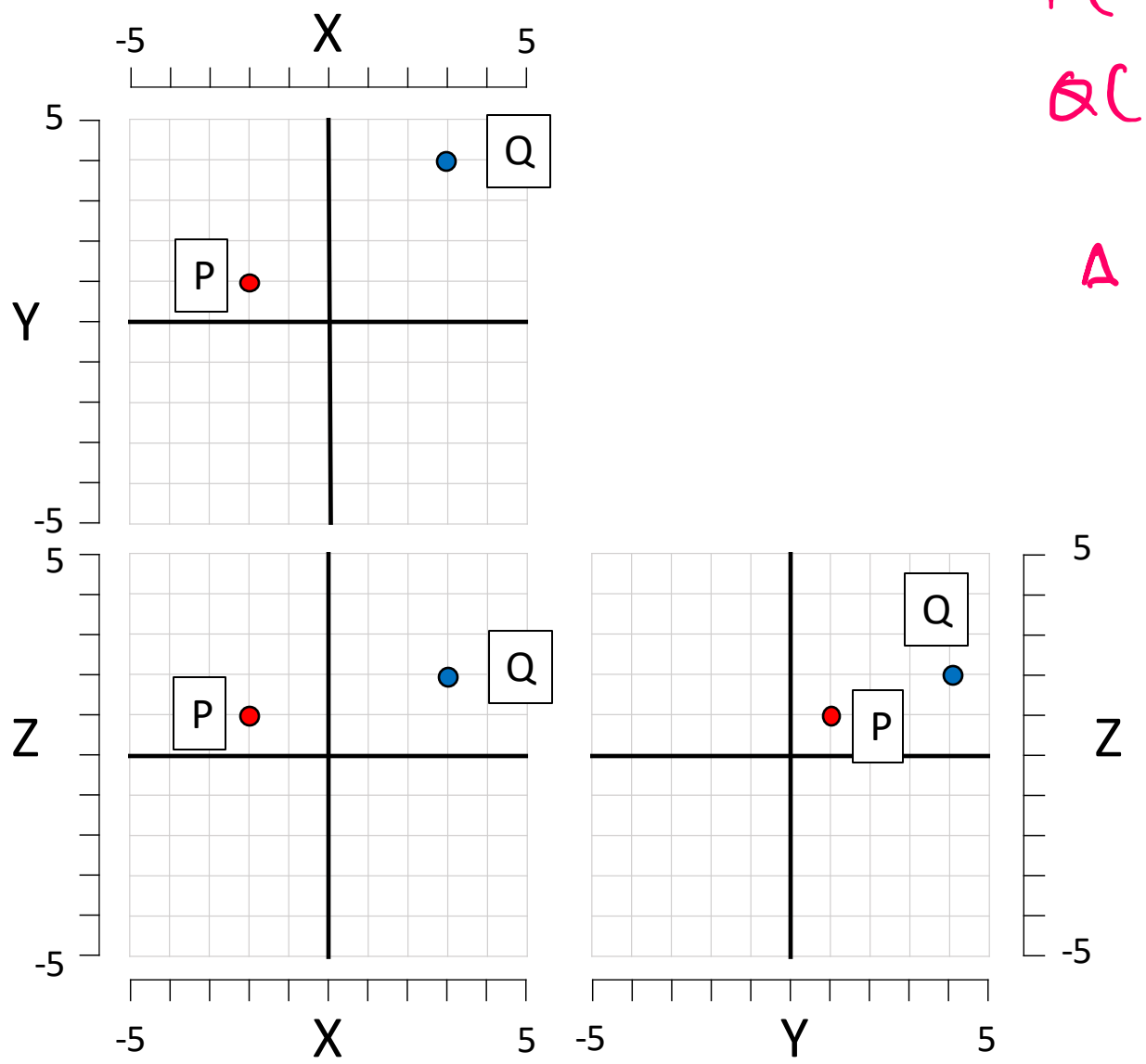
Goal	
4722	14
5722	16
Total Completed	
18	

1 Calculate T

P(-2, 1, 1)

Q(3, 4, 2)

Δ = (5, 3, 1)



P
-2
1
1
1

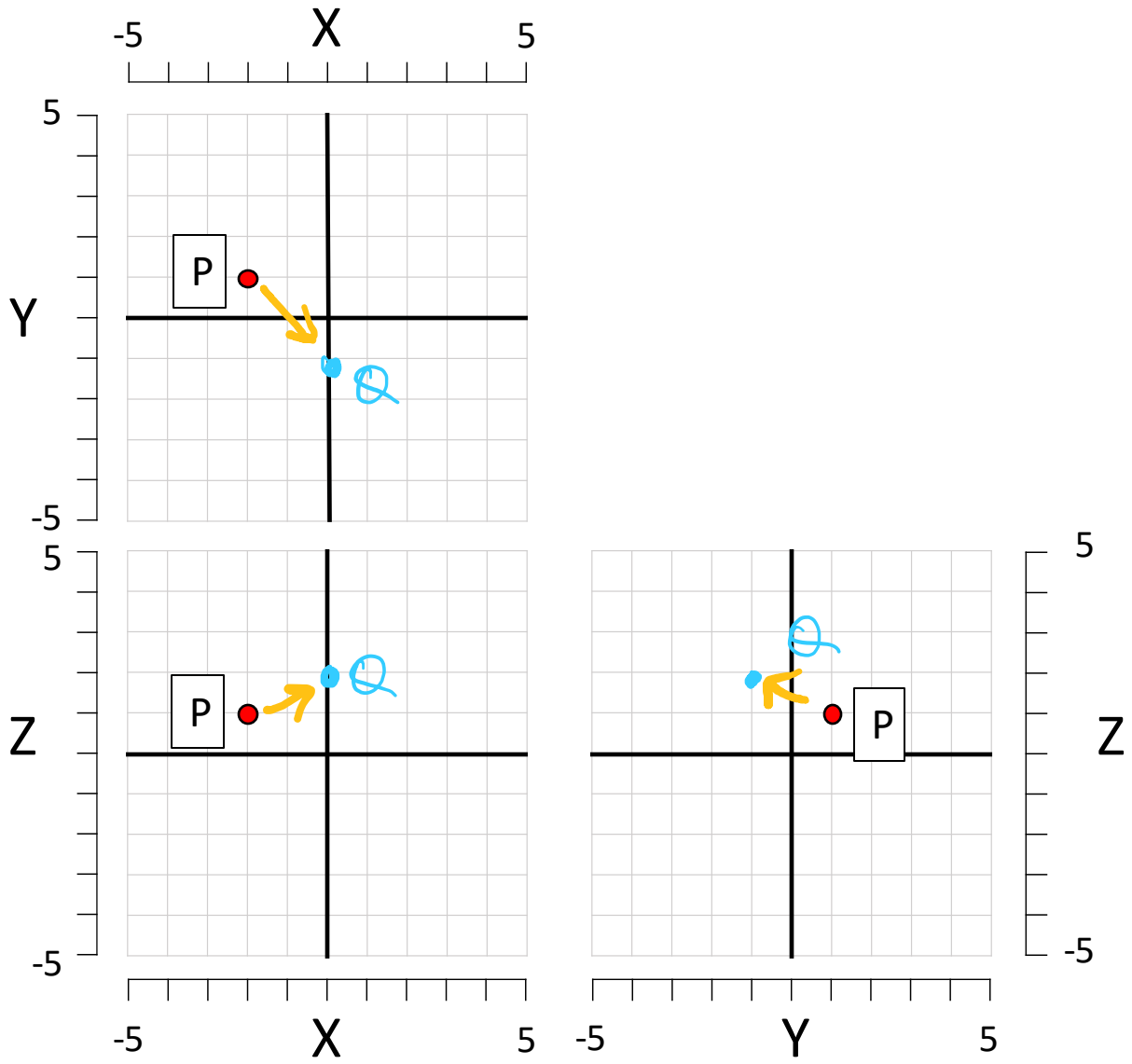
T

1			5
	1		3
		1	1
			1

T *P → Q

3
4
2
1

2 Calculate and Draw Q



P
-2
1
1
1

T

1			2
	1		-2
		1	1
			1

T *P → Q

0
-1
2
1

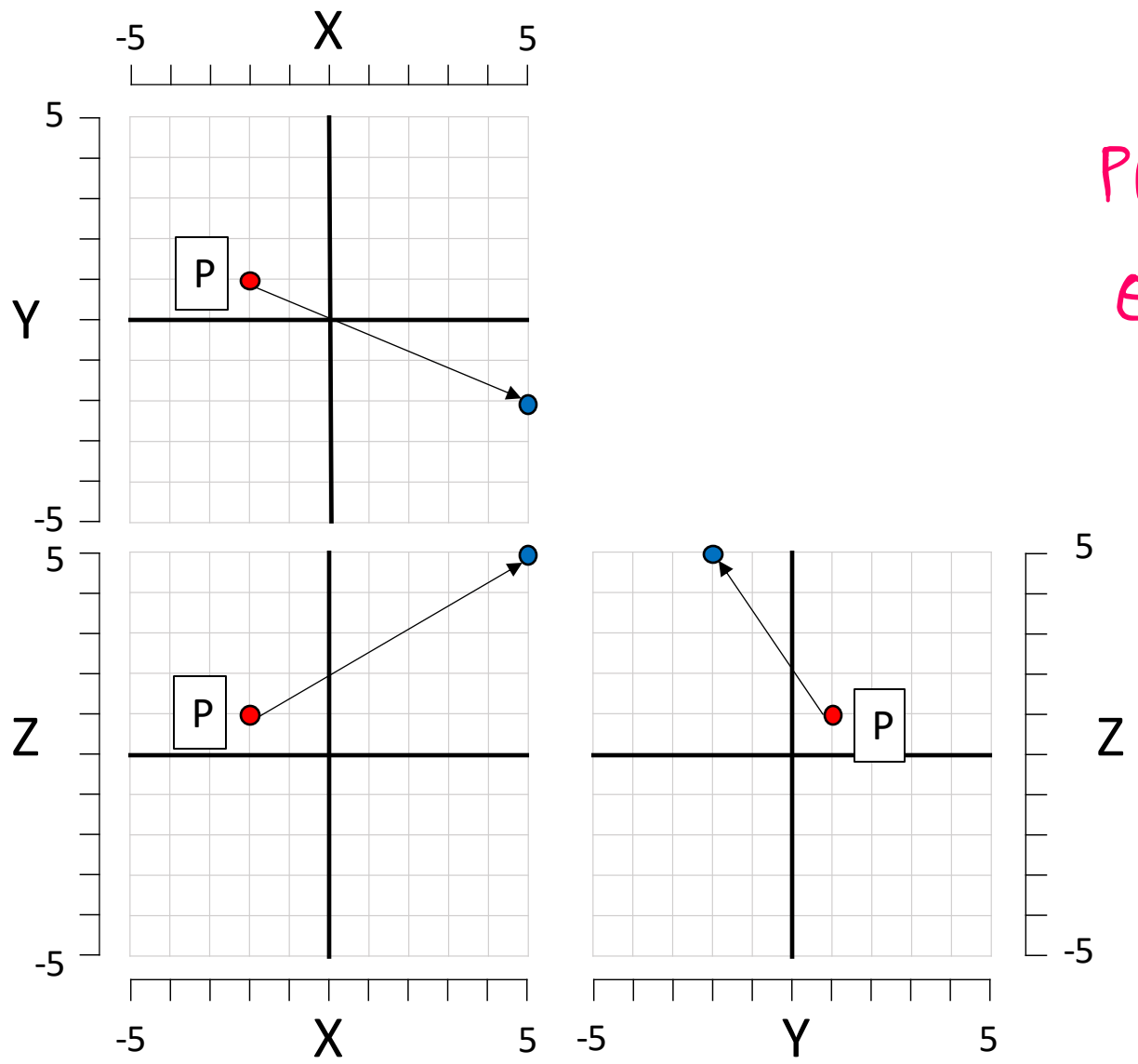
-2+2

1-2

1+1

1

3 Calculate T and Q



$P(-2,1,1)$

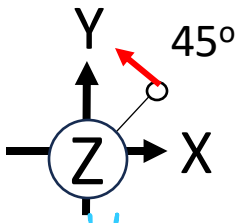
$Q(5,-2,5)$

$\Delta = (7,-3,4)$

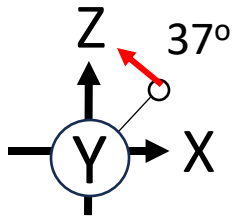
P
-2
1
1
1

T				T *P → Q	
1			7	5	-2+7
	1		-3	-2	1-3
		1	4	5	1+4
			1	1	1

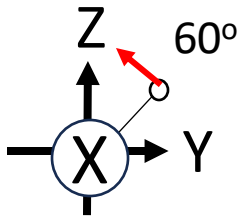
4 3D rotation notations → Matrices



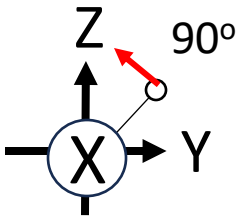
x	√2/2	-√2/2	
s	√2/2	√2/2	
		c	1



x	4/5		-3/5
		1	
s	3/5		4/5



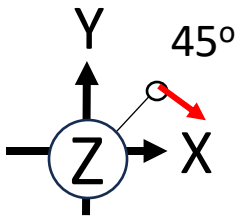
1		
c	1/2	-√3/2
	√3/2	1/2

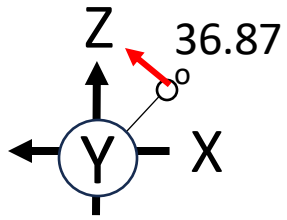


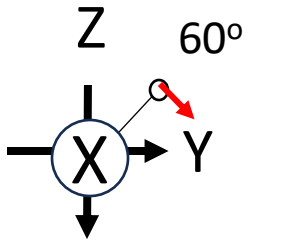
1		
c	0	-1
	1	0

degrees	30	37	45	53	60	90
sin(θ)	1/2	3/5	√2/2	4/5	√3/2	1
cos(θ)	√3/2	4/5	√2/2	3/5	1/2	0

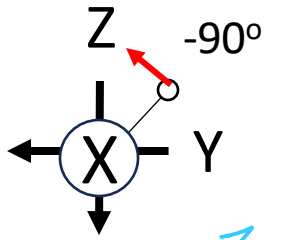
5 3D rotation notations → Matrices





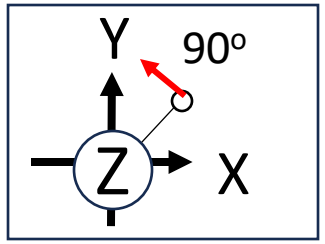


negative



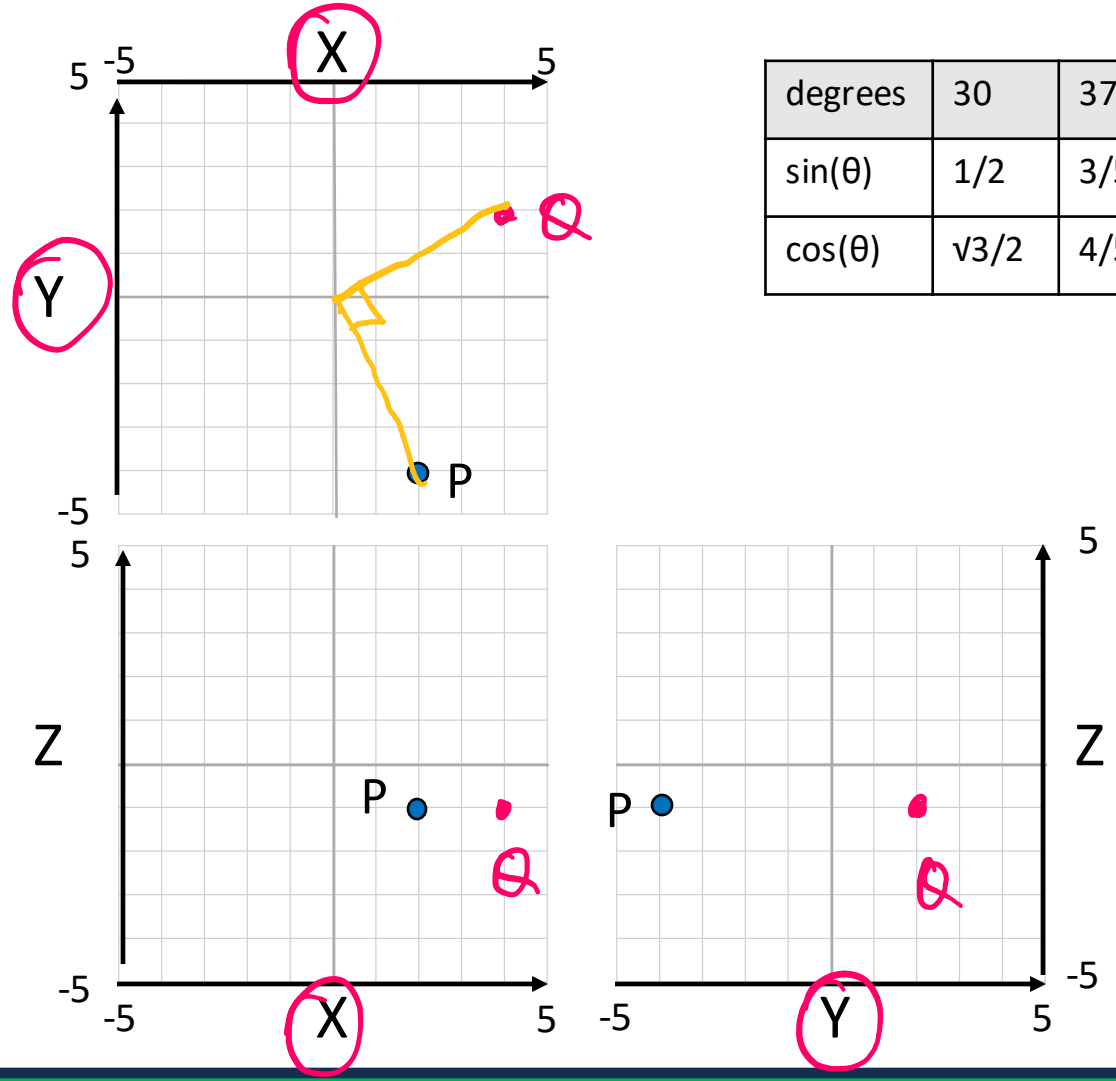
degrees	30	37	45	53	60	90
sin(θ)	1/2	3/5	√2/2	4/5	√3/2	1
cos(θ)	√3/2	4/5	√2/2	3/5	1/2	0

6



Calculate and Draw Q

P(2, -4, -1)



degrees	30	37	45	53	60	90
sin(θ)	1/2	3/5	√2/2	4/5	√3/2	1
cos(θ)	√3/2	4/5	√2/2	3/5	1/2	0

P
2
-4
-1
1

R

-5

C

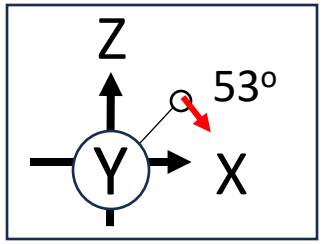
S

0	-1		0
1	0		0
	C	1	0
			1

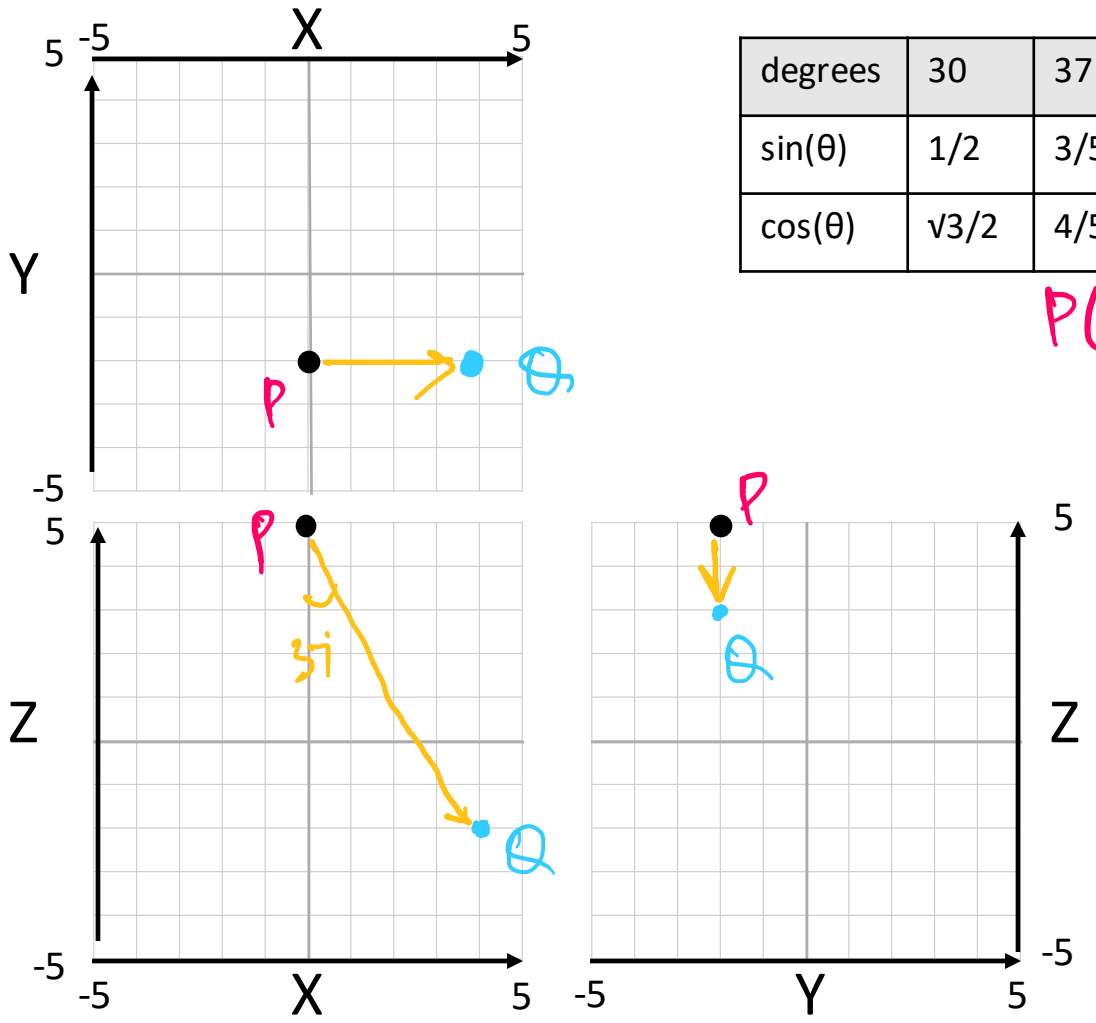
R*P
4
2
-1
1

Q

7



Rotate p along Y by (-53°) Calculate and draw Q



degrees	30	37	45	53	60	90
sin(θ)	1/2	3/5	√2/2	4/5	√3/2	1
cos(θ)	√3/2	4/5	√2/2	3/5	1/2	0

P(0,-2,5)

P
0
-2
5
1

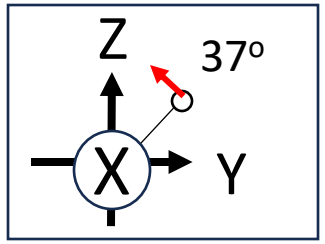
R

3/5		4/5	0
	1		0
-4/5		3/5	0
			1

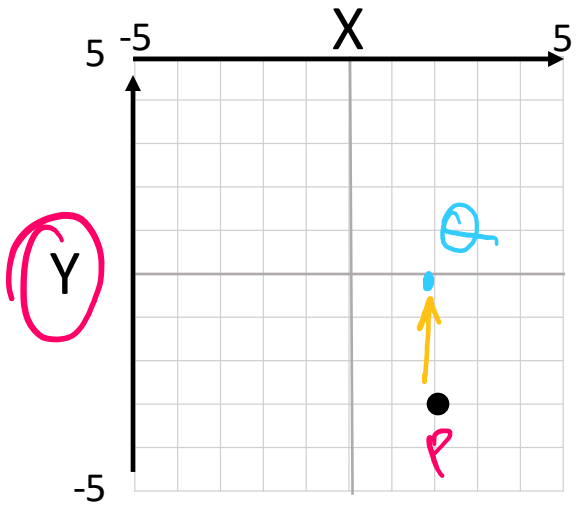
R*P

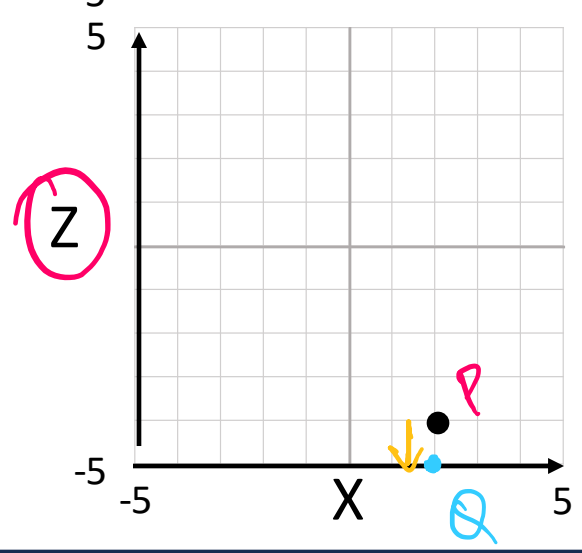
Q
4
-2
3
1

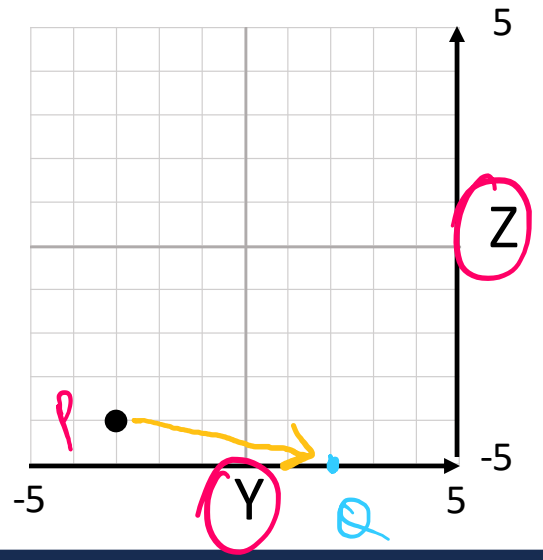
8



Rotate p along X by (37°)
Calculate and draw Q







degrees	30	37	45	53	60	90
sin(θ)	1/2	3/5	√2/2	4/5	√3/2	1
cos(θ)	√3/2	4/5	√2/2	3/5	1/2	0

P

2
-3
-4
1

R

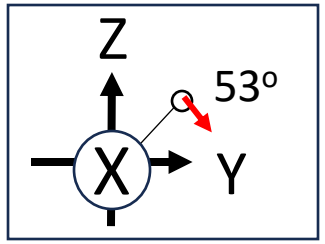
1	c	-s	0
	4/5	-3/5	0
	3/5	4/5	0
	s	c	1

R*P

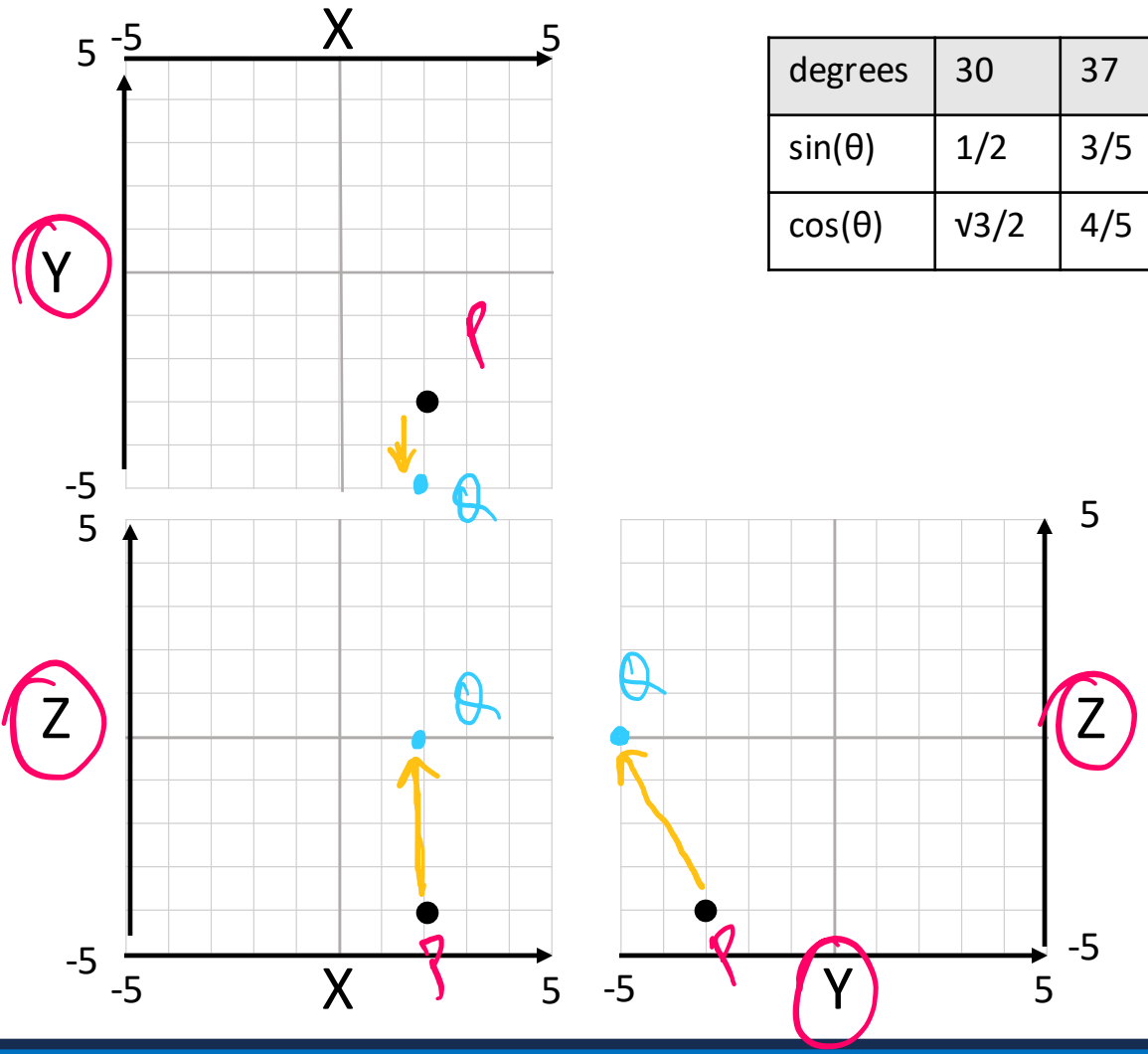
2
0
-5
1

Q

9



Rotate p along X by (-53°) Calculate and draw Q



degrees	30	37	45	53	60	90
sin(θ)	1/2	3/5	√2/2	4/5	√3/2	1
cos(θ)	√3/2	4/5	√2/2	3/5	1/2	0

P

2
-3
-4
1

R*P

R

1	c	s	0	2
	3/5	4/5	0	-5
	-4/5	3/5	0	0
	-s	c	1	1

Q

10 Order of rotations

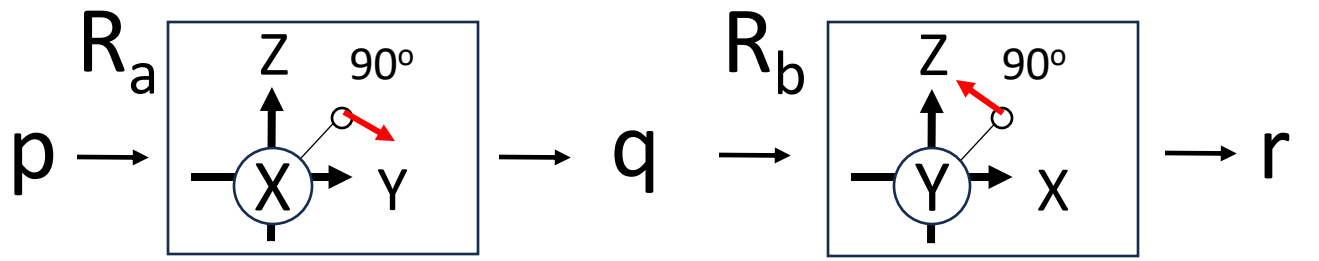
Given a set of rotations, R1, R2, and R3 to apply to a point p. Consider two different sequence of rotations as follows:

q_1 = (R1 * (R2 * (R3 * p)))
q_2 = (R3 * (R2 * (R1 * p)))

In general, which two statements are true

- ☐ A. $q_1 = q_2$ in 3D
- ☑ B. $q_1 \neq q_2$ in 3D
- ☑ C. $q_1 = q_2$ in 2D
- ☐ D. $q_1 \neq q_2$ in 2D

11 ☑ ☐



2	p
-4	
-1	
1	

degrees	30	37	45	53	60	90
sin(θ)	1/2	3/5	√2/2	4/5	√3/2	1
cos(θ)	√3/2	4/5	√2/2	3/5	1/2	0

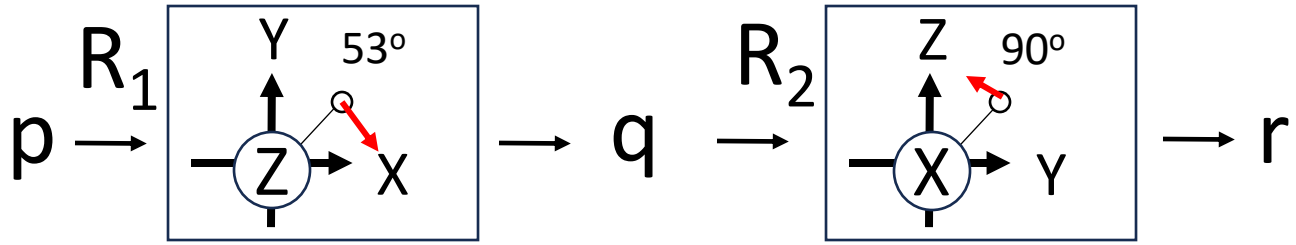
R_a (about y)

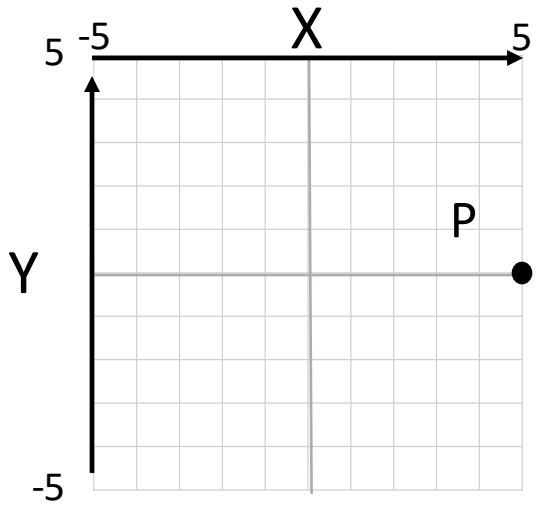
1	c	s	0	2	q
	0	1	0	-1	
	-1	0	0	4	
	-s	c	1	1	

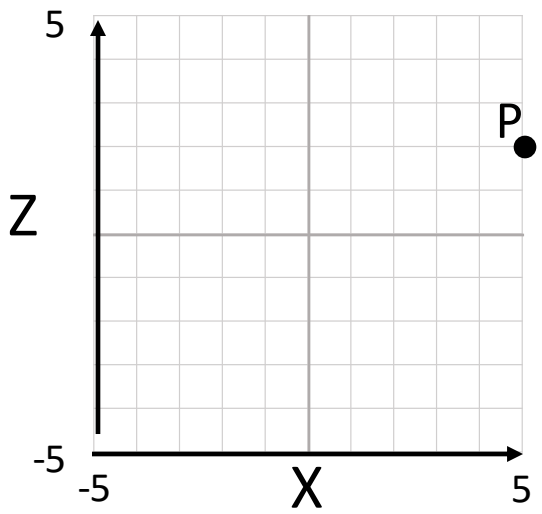
R_b (about z)

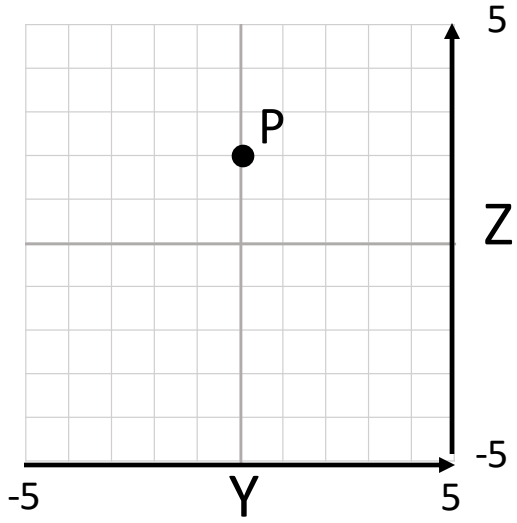
c		-1	0	-4	r
	1		0	-1	
1		0	0	2	
		c	1	1	

12









degrees	30	37	45	53	60	90
sin(θ)	1/2	3/5	√2/2	4/5	√3/2	1
cos(θ)	√3/2	4/5	√2/2	3/5	1/2	0

p

5
0
2
1

q

3/5	4/5		0
-4/5	3/5		0
-s	c	1	0
			1

3
-4
2
1

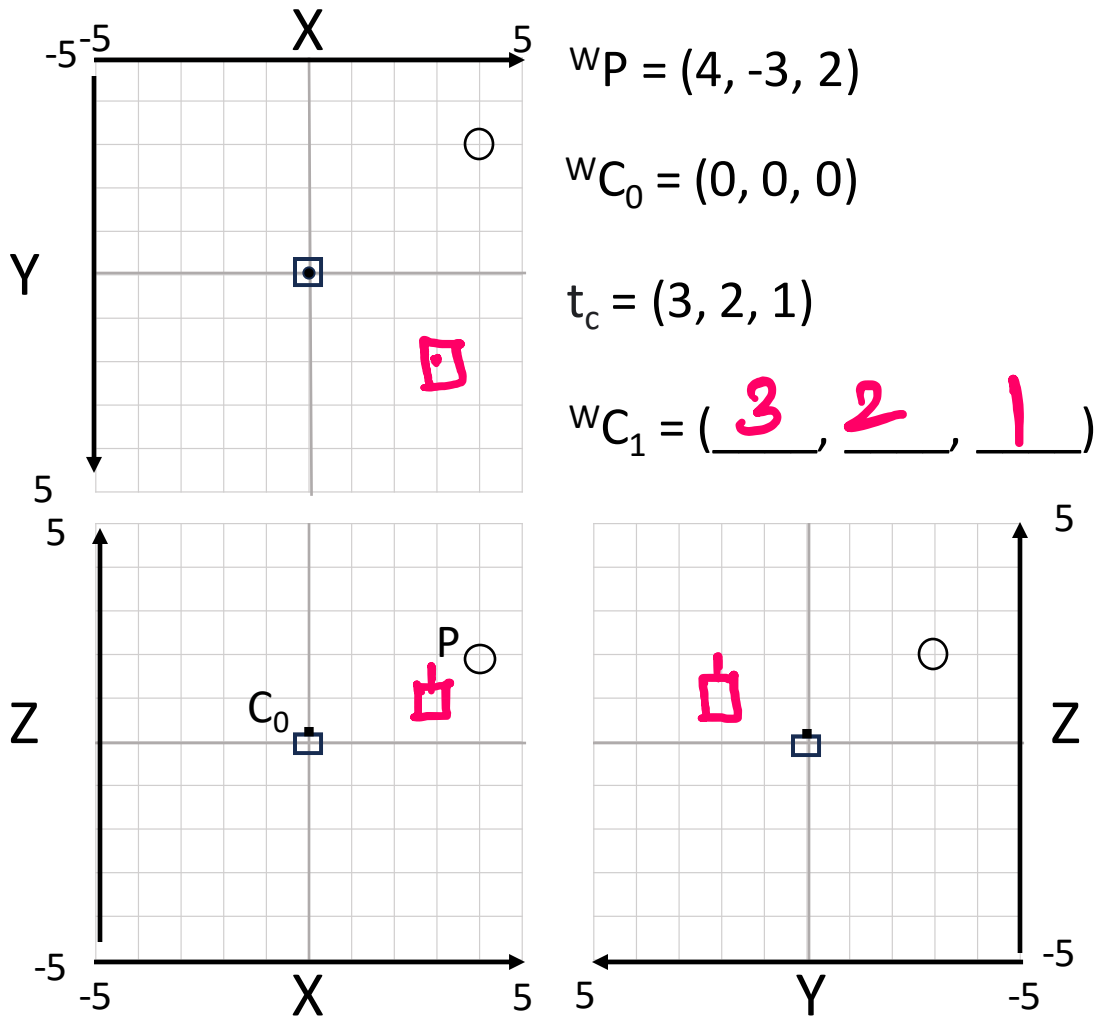
r

1			0
c	0	-1	-s0
	1	0	c0
	s		1

3
-2
-4
1

13 Move the camera in the world; Calculate and draw ${}^{W}C_1$

World Coordinate System



${}^{W}P = (4, -3, 2)$

${}^{W}C_0 = (0, 0, 0)$

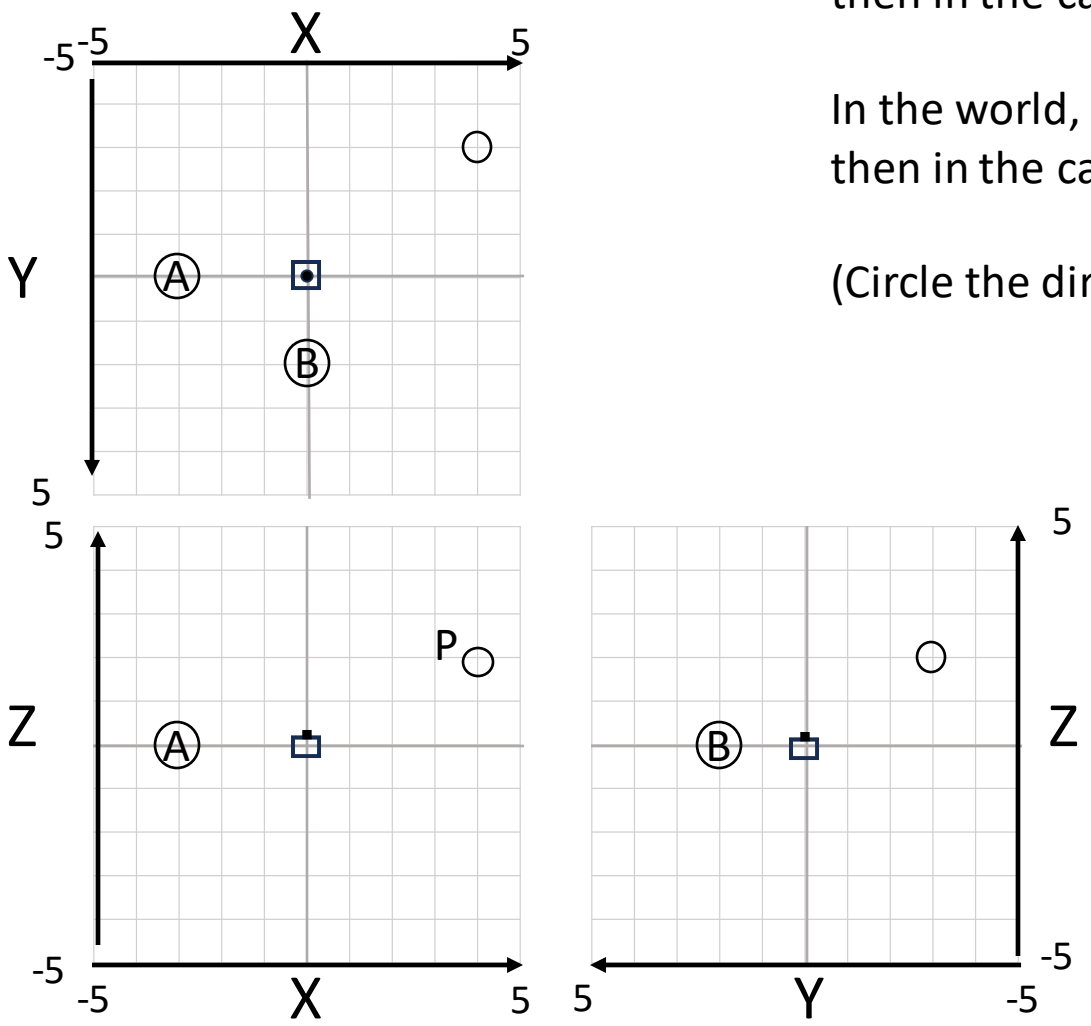
$t_c = (3, 2, 1)$

${}^{W}C_1 = (\underline{3}, \underline{2}, \underline{1})$

Reminder: In the world coordinate, Y's direction is downward in "axial", and left in "sagittal"

14 P moves in the Camera Coordinate system the Calculate and draw ^{C1}P

World Coordinate System

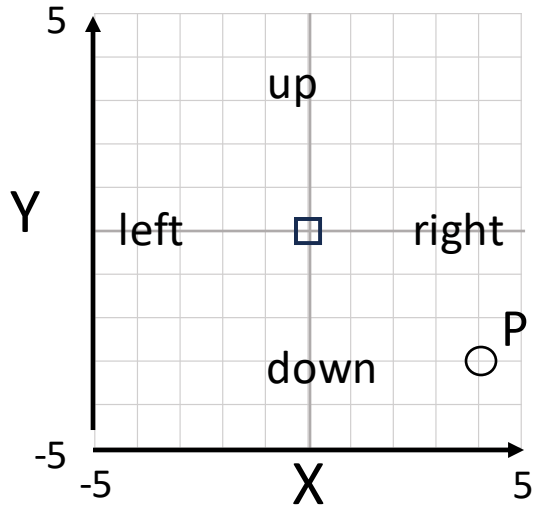


In the world, if the camera moves to A,
then in the camera view, P moved { left | right | up | down }

In the world, if the camera moves to B,
then in the camera view, P moved { left | right | up | down }

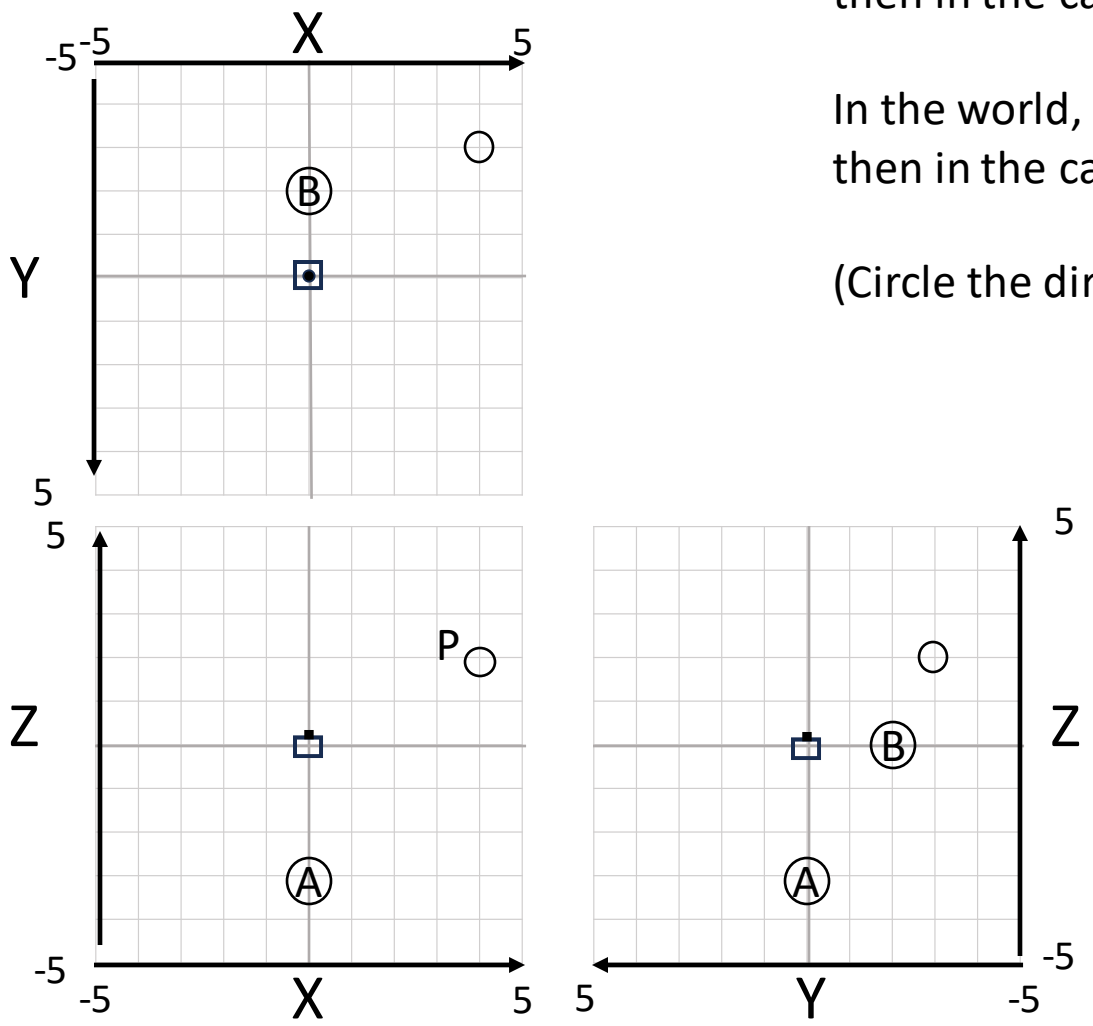
(Circle the direction. Hint: draw the body)

Camera Coordinate System
X-Y plane (coronal) only



15 ✓ ○ P moves in the Camera Coordinate system the Calculate and draw ^{C1}P

World Coordinate System

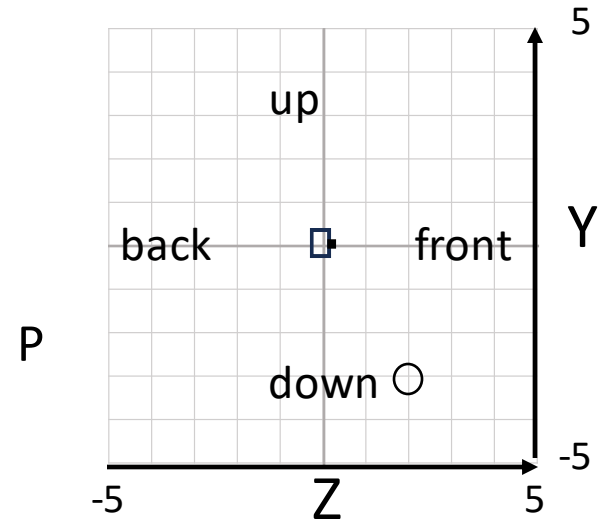


In the world, if the camera moves to A,
then in the camera view, P moved { front | back | up | down }

In the world, if the camera moves to B,
then in the camera view, P moved {front | back | up | down }

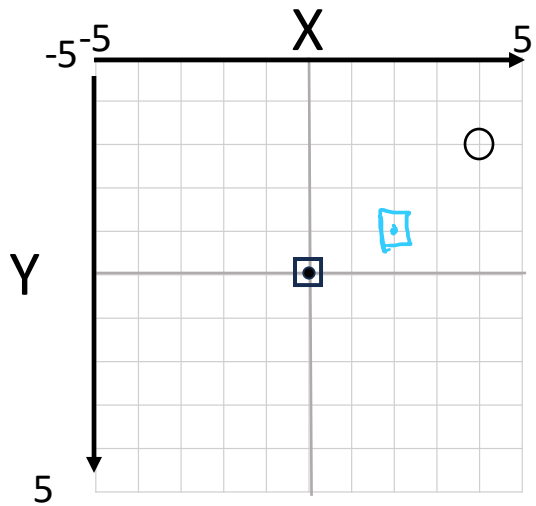
(Circle the direction. Hint: draw the body)

Camera Coordinate System
Z-Y plane (sagittal) only



16 Infer camera movement from point correspondence ^{C0}p and ^{C1}p. Draw $^{W}C_1$

World Coordinate System

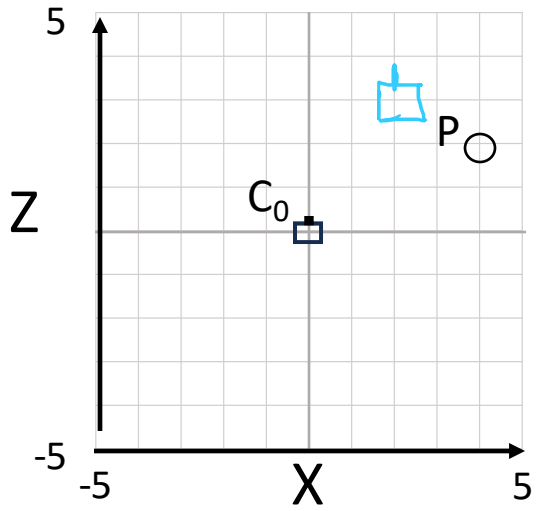


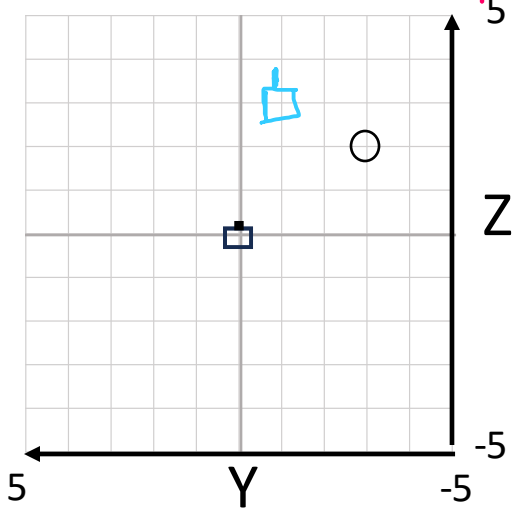
$^{W}P = (4, -3, 2)$

$^{W}C_0 = (0, 0, 0)$

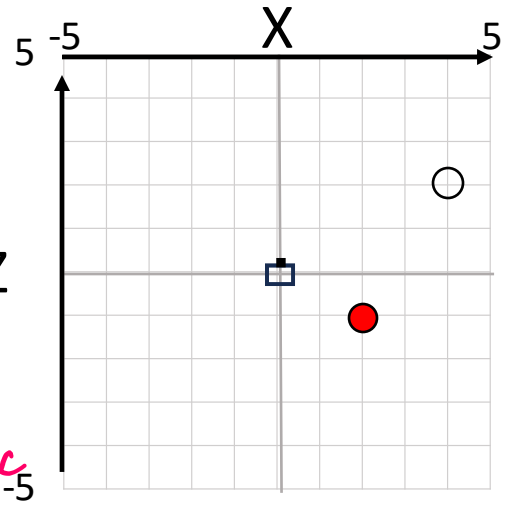
$t_c = (\underline{2}, \underline{-1}, \underline{3})$ $t_c = -t_p$

$^{W}C_1 = (\underline{2}, \underline{-1}, \underline{3})$ $Wc_1 = Wc_0 + t_c$





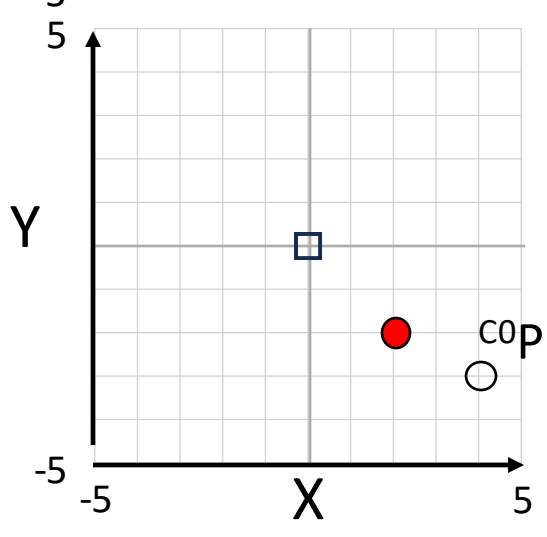
Camera Coordinate System $^{C1}p = {}^{C0}p + t_p$

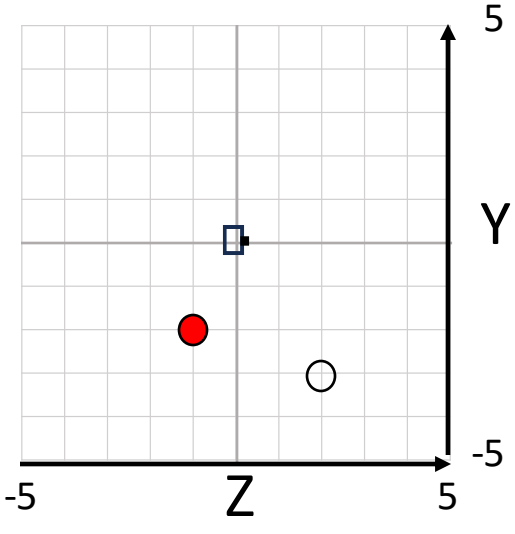


$^{C0}P = (4, -3, 2)$

$t_p = (\underline{-2}, \underline{1}, \underline{-3})$

$^{C1}P = (\underline{2}, \underline{-2}, \underline{-1})$





17 ☑ ○ Calculate camera's movement: Tc = (-1, -4, 6)

P1	P2	P3
5	3	2
-4	0	1
4	5	5
1	1	1

$t_c = -t_p$

Tp

1	0	0	1
0	1	0	4
0	0	1	-6
0	0	0	1

6	4	3
0	4	5
-2	-1	-1
1	1	1

18 Calculate camera's movement: Tc = (-2, -5, 5)

The measurements of point correspondences P and P' may not be perfect. Thus, you may derive a different Tp from each point correspondence.

Apply a simple "majority vote" to determine the Tp to solve this problem.

P1	P2	P3	P4	P5
5	5	3	3	2
-4	-3	0	1	1
4	4	5	5	5
1	1	1	1	1

Tp

1	0	0	2
0	1	0	5
0	0	1	-5
0	0	0	1

P1'	P2'	P3'	P4'	P5'
7	7	5	5	4
1	1	5	5	6
-1	-1	0	0	0
1	1	1	1	1