Chapter 2 Solutions for Introduction to Robotics

1. a) Use (2.3) to obtain

$${}^{A}_{B}R = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & -1 & 0 \end{bmatrix}$$

b) Use (2.74) to get

 $\begin{array}{l} \alpha = 90 \text{ degrees} \\ \beta = 90 \text{ degrees} \\ \gamma = -90 \text{ degrees} \end{array}$

2. a) Use (2.64) to obtain

$${}^{A}_{B}R = \begin{bmatrix} .330 & -.770 & .547 \\ .908 & .418 & .0396 \\ -.259 & .483 & .837 \end{bmatrix}$$

- b) Answer is the same as in (a) according to (2.71)
- 3. Use (2.19) to obtain the transformation matrices. The rotation is X-Y-Z fixed angles, so use (2.64) for that 3×3 submatrix, with angles

$$\gamma = 0 \text{ degrees}$$

$$\beta = -\sin^{-1} \left(\frac{\text{tripod_height}}{\text{distance_along_optical_axis}} \right) = -\sin^{-1} \left(\frac{1.5}{5} \right) = -107 \text{ degrees}$$

$$\alpha_C = 0 \text{ degrees}$$

$$\alpha_D = 120 \text{ degrees}$$

$$\alpha_E = 240 \text{ degrees}$$

The position vectors to the camera-frame origins are

$${}^{B}P_{CORG} = \begin{bmatrix} \text{horizontal_distance} \\ 0 \\ \text{tripod_height} \end{bmatrix} = \begin{bmatrix} 4.77 \\ 0 \\ 1.50 \end{bmatrix}$$
$${}^{B}P_{DORG} = \begin{bmatrix} \text{horizontal_distance} \times \cos \alpha_D \\ \text{horizontal_distance} \times \sin \alpha_D \\ \text{tripod_height} \end{bmatrix} = \begin{bmatrix} -2.39 \\ 4.13 \\ 1.5 \end{bmatrix}$$
$${}^{B}P_{EORG} = \begin{bmatrix} \text{horizontal_distance} \times \cos \alpha_E \\ \text{horizontal_distance} \times \sin \alpha_E \\ \text{tripod_height} \end{bmatrix} = \begin{bmatrix} -2.38 \\ -4.13 \\ 1.50 \end{bmatrix},$$

where horizontal_distance = $\sqrt{(\text{distance_along_optical_axis})^2 - (\text{tripod_height})^2}$. Combining the rotation and translation yields the transformation matrices via (2.19) as

$${}^{B}_{C}T = \begin{bmatrix} -.300 & 0 & -.954 & 4.77 \\ 0 & 1.00 & 0 & 0 \\ .954 & 0 & -.300 & 1.50 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$
$${}^{B}_{D}T = \begin{bmatrix} .150 & -.866 & .477 & -2.39 \\ -.260 & -.500 & -.826 & 4.13 \\ .954 & 0 & -.300 & 1.50 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$
$${}^{B}_{E}T = \begin{bmatrix} .150 & .866 & .477 & -2.39 \\ .260 & -.500 & .826 & -4.13 \\ .954 & 0 & -.300 & 1.50 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

4. The camera-frame origin is located at ${}^{B}P_{CORG} = \begin{bmatrix} 7 & -2 & 5 \end{bmatrix}^{\mathsf{T}}$. Use (2.19) to get the transformation, ${}^{B}_{C}T$. The rotation is Z-Y-X Euler angles, so use (2.71) with

 $\begin{aligned} \alpha &= 0 \text{ degrees} \\ \beta &= -110 \text{ degrees} \\ \gamma &= -20 \text{ degrees} \end{aligned}$

to get

$${}^{B}_{C}T = \begin{bmatrix} -.342 & .321 & -.883 & 7.00 \\ 0 & .940 & .342 & -2.00 \\ .940 & .117 & -.321 & 5.00 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

© 2018 Pearson Education, Inc., Hoboken, NJ. All rights reserved. This material is protected under all copyright laws as they currently exist. No portion of this material may be reproduced, in any form or by any means, without permission in writing from the publisher.

Solutions Manual for Introduction to Robotics Mechanics and Control 4th Edition by Craig IBSN 9780133489798

Full Download: http://downloadlink.org/product/solutions-manual-for-introduction-to-robotics-mechanics-and-control-4th-edition-

$${}^{B}P_{1} = {}^{B}P_{0} + 5 {}^{B}V_{0} = [9.5 \quad 1.00 \quad -1.50]^{\mathsf{T}}$$

The object's position in $\{A\}$ is

$${}^{A}P_{1} = {}^{A}_{B}T {}^{B}P_{1} = \begin{bmatrix} -4.89 & 2.11 & 3.60 \end{bmatrix}^{\mathsf{T}}$$

6. (2.1)

$$R = \operatorname{rot}(Y, \phi) \operatorname{rot}(Z, \theta)$$
$$= \begin{bmatrix} c\phi & 0 & s\phi \\ 0 & 1 & 0 \\ -s\phi & 0 & c\phi \end{bmatrix} \begin{bmatrix} c\theta & -s\theta & 0 \\ s\theta & c\theta & 0 \\ 0 & 0 & 1 \end{bmatrix}$$
$$= \begin{bmatrix} c\phi c\theta & -c\phi s\theta & s\phi \\ s\theta & c\theta & 0 \\ -s\phi c\theta & s\phi s\theta & c\phi \end{bmatrix}$$

7. (2.2)

$$R = \operatorname{rot}(\hat{X}, 60) \operatorname{rot}(\hat{Y}, -45)$$

$$= \begin{bmatrix} 1 & 0 & 0 \\ 0 & .500 & -.866 \\ 0 & .866 & .500 \end{bmatrix} \begin{bmatrix} .707 & 0 & -.707 \\ 0 & 1 & 0 \\ .707 & 0 & .707 \end{bmatrix}$$

$$= \begin{bmatrix} .707 & 0 & -.707 \\ -.612 & .500 & -.612 \\ .353 & .866 & .353 \end{bmatrix}$$

8. (2.12) Velocity is a "free vector" and only will be affected by rotation, and not by translation:

$${}^{A}V = {}^{A}_{B}R^{B}V = \begin{bmatrix} .707 & 0 & -.707 \\ -.612 & .500 & -.612 \\ .353 & .866 & .353 \end{bmatrix} \begin{bmatrix} 30.0 \\ 40.0 \\ 50.0 \end{bmatrix}$$
$$= \begin{bmatrix} -14.1 & -29.0 & 62.9 \end{bmatrix}^{\mathsf{T}}$$

9. (2.31)

$${}_{B}^{C}T = \begin{bmatrix} 0 & 0 & -1 & 2 \\ .500 & -.866 & 0 & 0 \\ -.866 & -.500 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

10. (2.37) Using (2.45) we get that

$${}^{B}P_{AORG} = -{}^{A}_{B}R^{\mathsf{T}\,A}P_{AORG} = - \begin{bmatrix} .25 & .87 & .43 \\ .43 & -.50 & .75 \\ .86 & .00 & -.50 \end{bmatrix} \begin{bmatrix} 5.0 \\ -4.0 \\ 3.0 \end{bmatrix} = \begin{bmatrix} .94 \\ -6.4 \\ -2.8 \end{bmatrix}$$

© 2018 Pearson Education, Inc., Hoboken, NJ. All rights reserved. This material is protected under all copyright laws as they currently exist. No portion of this material may be reproduced, in any form or by any means, without permission in writing from the publisher. Full all chapters instant download please go to Solutions Manual, Test Bank site: downloadlink.org