

学籍番号: _____

名前: _____

右図の2自由度のロボットアームがある。このとき、先端位置Pは下式で計算できる。

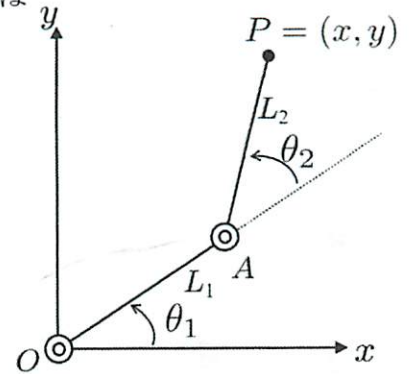
$$\begin{cases} x = L_1 \cos \theta_1 + L_2 \cos(\theta_1 + \theta_2) \\ y = L_1 \sin \theta_1 + L_2 \sin(\theta_1 + \theta_2) \end{cases}$$

$L_1=1\text{m}$, $L_2=1\text{m}$, $\theta_1=\frac{\pi}{4}\text{rad}$, $\theta_2=\frac{\pi}{4}\text{rad}$ のとき、以下の問に答えよ。

$\sin \rightarrow S$, $\cos \rightarrow C$ と略記する。

問1. ヤコビ行列 J を求めよ

$$\begin{aligned} J &= \begin{bmatrix} \frac{\partial x}{\partial \theta_1} & \frac{\partial x}{\partial \theta_2} \\ \frac{\partial y}{\partial \theta_1} & \frac{\partial y}{\partial \theta_2} \end{bmatrix} = \begin{bmatrix} -L_1 S\theta_1 - L_2 S(\theta_1 + \theta_2) & -L_2 S(\theta_1 + \theta_2) \\ L_1 C\theta_1 + L_2 C(\theta_1 + \theta_2) & L_2 C(\theta_1 + \theta_2) \end{bmatrix} \\ &= \begin{bmatrix} -1 \cdot S\frac{\pi}{4} - 1 \cdot S(\frac{\pi}{4} + \frac{\pi}{4}) & -1 \cdot S(\frac{\pi}{4} + \frac{\pi}{4}) \\ 1 \cdot C\frac{\pi}{4} + 1 \cdot C(\frac{\pi}{4} + \frac{\pi}{4}) & 1 \cdot C(\frac{\pi}{4} + \frac{\pi}{4}) \end{bmatrix} \\ &= \begin{bmatrix} -\frac{1}{\sqrt{2}} - 1 & -1 \\ \frac{1}{\sqrt{2}} & 0 \end{bmatrix} \end{aligned}$$



問2. x 方向に 0.1m/s , y 方向に -0.2m/s で動かしたいときに必要な関節の角速度, $\dot{\theta}_1$, $\dot{\theta}_2$ [rad/s] を求めよ。

$$\begin{bmatrix} \dot{\theta}_1 \\ \dot{\theta}_2 \end{bmatrix} = J^{-1} \begin{bmatrix} 0.1 \\ -0.2 \end{bmatrix}$$

$$= \left(\frac{1}{|J|} \begin{bmatrix} 0 & 1 \\ -\frac{1}{\sqrt{2}} & -\frac{1}{\sqrt{2}} - 1 \end{bmatrix} \right) \begin{bmatrix} 0.1 \\ -0.2 \end{bmatrix}$$

$$= \frac{1}{\left\{ \left(-\frac{1}{\sqrt{2}} - 1 \right) \cdot 0 - (-1) \cdot \frac{1}{\sqrt{2}} \right\}} \begin{bmatrix} 0 & 1 \\ -\frac{1}{\sqrt{2}} & -\frac{1}{\sqrt{2}} - 1 \end{bmatrix} \begin{bmatrix} 0.1 \\ -0.2 \end{bmatrix}$$

$$= \left(\sqrt{2} \begin{bmatrix} 0 & 1 \\ -\frac{1}{\sqrt{2}} & -\frac{1}{\sqrt{2}} - 1 \end{bmatrix} \right) \begin{bmatrix} 0.1 \\ -0.2 \end{bmatrix}$$

$$= \begin{bmatrix} 0 & \sqrt{2} \\ -1 & -1 - \sqrt{2} \end{bmatrix} \begin{bmatrix} 0.1 \\ -0.2 \end{bmatrix} = \begin{bmatrix} 0 \times 0.1 + \sqrt{2} \times (-0.2) \\ (-1) \times 0.1 + (-1 - \sqrt{2}) \times (-0.2) \end{bmatrix}$$

$$= \begin{bmatrix} -0.2\sqrt{2} \\ -0.1 + 0.2 + 0.2\sqrt{2} \end{bmatrix} = \begin{bmatrix} -0.2\sqrt{2} \\ 0.2\sqrt{2} + 0.1 \end{bmatrix}$$

$$\begin{aligned} \begin{bmatrix} \dot{\theta}_1 \\ \dot{\theta}_2 \end{bmatrix} &= \begin{bmatrix} -0.2\sqrt{2} \\ 0.2\sqrt{2} + 0.1 \end{bmatrix} \\ \therefore \begin{cases} \dot{\theta}_1 &= -0.2\sqrt{2} \\ \dot{\theta}_2 &= 0.2\sqrt{2} + 0.1 \end{cases} \end{aligned}$$

rad/s

1

1. The first part of the paper is devoted to a discussion of the general theory of the problem.

2. The second part is devoted to a discussion of the special case of the problem.

3. The third part is devoted to a discussion of the numerical results of the calculations.

4. The fourth part is devoted to a discussion of the conclusions of the paper.

5. The fifth part is devoted to a discussion of the bibliography.

6. The sixth part is devoted to a discussion of the appendix.

7. The seventh part is devoted to a discussion of the references.

8. The eighth part is devoted to a discussion of the summary.

9. The ninth part is devoted to a discussion of the conclusions.

10. The tenth part is devoted to a discussion of the bibliography.

11. The eleventh part is devoted to a discussion of the appendix.

12. The twelfth part is devoted to a discussion of the references.

13. The thirteenth part is devoted to a discussion of the summary.

14. The fourteenth part is devoted to a discussion of the conclusions.

15. The fifteenth part is devoted to a discussion of the bibliography.

16. The sixteenth part is devoted to a discussion of the appendix.

17. The seventeenth part is devoted to a discussion of the references.

18. The eighteenth part is devoted to a discussion of the summary.

19. The nineteenth part is devoted to a discussion of the conclusions.

20. The twentieth part is devoted to a discussion of the bibliography.

21. The twenty-first part is devoted to a discussion of the appendix.

22. The twenty-second part is devoted to a discussion of the references.

23. The twenty-third part is devoted to a discussion of the summary.

24. The twenty-fourth part is devoted to a discussion of the conclusions.

25. The twenty-fifth part is devoted to a discussion of the bibliography.

26. The twenty-sixth part is devoted to a discussion of the appendix.

27. The twenty-seventh part is devoted to a discussion of the references.

28. The twenty-eighth part is devoted to a discussion of the summary.

29. The twenty-ninth part is devoted to a discussion of the conclusions.

30. The thirtieth part is devoted to a discussion of the bibliography.

31. The thirty-first part is devoted to a discussion of the appendix.

32. The thirty-second part is devoted to a discussion of the references.

33. The thirty-third part is devoted to a discussion of the summary.

34. The thirty-fourth part is devoted to a discussion of the conclusions.

35. The thirty-fifth part is devoted to a discussion of the bibliography.

36. The thirty-sixth part is devoted to a discussion of the appendix.

37. The thirty-seventh part is devoted to a discussion of the references.

38. The thirty-eighth part is devoted to a discussion of the summary.

39. The thirty-ninth part is devoted to a discussion of the conclusions.

40. The fortieth part is devoted to a discussion of the bibliography.

41. The forty-first part is devoted to a discussion of the appendix.

42. The forty-second part is devoted to a discussion of the references.

43. The forty-third part is devoted to a discussion of the summary.

44. The forty-fourth part is devoted to a discussion of the conclusions.

45. The forty-fifth part is devoted to a discussion of the bibliography.

46. The forty-sixth part is devoted to a discussion of the appendix.

47. The forty-seventh part is devoted to a discussion of the references.

48. The forty-eighth part is devoted to a discussion of the summary.

49. The forty-ninth part is devoted to a discussion of the conclusions.

50. The fiftieth part is devoted to a discussion of the bibliography.

51. The fifty-first part is devoted to a discussion of the appendix.

52. The fifty-second part is devoted to a discussion of the references.

53. The fifty-third part is devoted to a discussion of the summary.

54. The fifty-fourth part is devoted to a discussion of the conclusions.

55. The fifty-fifth part is devoted to a discussion of the bibliography.

56. The fifty-sixth part is devoted to a discussion of the appendix.

57. The fifty-seventh part is devoted to a discussion of the references.

58. The fifty-eighth part is devoted to a discussion of the summary.

59. The fifty-ninth part is devoted to a discussion of the conclusions.

60. The sixtieth part is devoted to a discussion of the bibliography.

61. The sixty-first part is devoted to a discussion of the appendix.

62. The sixty-second part is devoted to a discussion of the references.

63. The sixty-third part is devoted to a discussion of the summary.

64. The sixty-fourth part is devoted to a discussion of the conclusions.

65. The sixty-fifth part is devoted to a discussion of the bibliography.

66. The sixty-sixth part is devoted to a discussion of the appendix.

67. The sixty-seventh part is devoted to a discussion of the references.

68. The sixty-eighth part is devoted to a discussion of the summary.

69. The sixty-ninth part is devoted to a discussion of the conclusions.

70. The seventieth part is devoted to a discussion of the bibliography.

71. The seventy-first part is devoted to a discussion of the appendix.

72. The seventy-second part is devoted to a discussion of the references.

73. The seventy-third part is devoted to a discussion of the summary.

74. The seventy-fourth part is devoted to a discussion of the conclusions.

75. The seventy-fifth part is devoted to a discussion of the bibliography.

76. The seventy-sixth part is devoted to a discussion of the appendix.

77. The seventy-seventh part is devoted to a discussion of the references.

78. The seventy-eighth part is devoted to a discussion of the summary.

79. The seventy-ninth part is devoted to a discussion of the conclusions.

80. The eightieth part is devoted to a discussion of the bibliography.

81. The eighty-first part is devoted to a discussion of the appendix.

82. The eighty-second part is devoted to a discussion of the references.

83. The eighty-third part is devoted to a discussion of the summary.

84. The eighty-fourth part is devoted to a discussion of the conclusions.

85. The eighty-fifth part is devoted to a discussion of the bibliography.

86. The eighty-sixth part is devoted to a discussion of the appendix.

87. The eighty-seventh part is devoted to a discussion of the references.

88. The eighty-eighth part is devoted to a discussion of the summary.

89. The eighty-ninth part is devoted to a discussion of the conclusions.

90. The ninetieth part is devoted to a discussion of the bibliography.

91. The ninety-first part is devoted to a discussion of the appendix.

92. The ninety-second part is devoted to a discussion of the references.

93. The ninety-third part is devoted to a discussion of the summary.

94. The ninety-fourth part is devoted to a discussion of the conclusions.

95. The ninety-fifth part is devoted to a discussion of the bibliography.

96. The ninety-sixth part is devoted to a discussion of the appendix.

97. The ninety-seventh part is devoted to a discussion of the references.

98. The ninety-eighth part is devoted to a discussion of the summary.

99. The ninety-ninth part is devoted to a discussion of the conclusions.

100. The hundredth part is devoted to a discussion of the bibliography.

