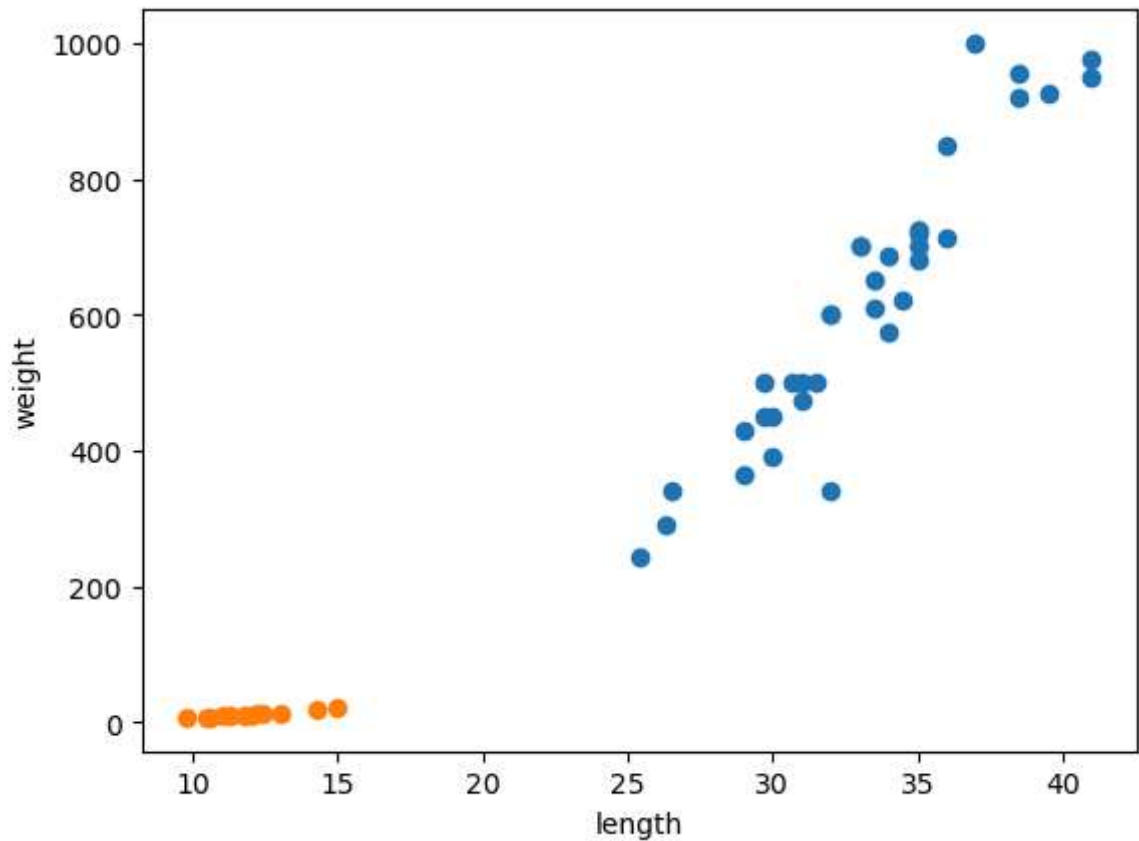


빙어 데이터 준비하기

```
In [3]: smelt_length = [9.8, 10.5, 10.6, 11.0, 11.2, 11.3, 11.8, 11.8, 12.0, 12.2, 12.4, 13.0, 13.4, 13.5, 13.8, 14.0, 14.5, 14.8, 15.0, 15.5, 15.8, 16.0, 16.5, 16.8, 17.0, 17.5, 17.8, 18.0, 18.5, 18.8, 19.0, 19.5, 19.8, 20.0, 20.5, 20.8, 21.0, 21.5, 21.8, 22.0, 22.5, 22.8, 23.0, 23.5, 23.8, 24.0, 24.5, 24.8, 25.0, 25.5, 25.8, 26.0, 26.5, 26.8, 27.0, 27.5, 27.8, 28.0, 28.5, 28.8, 29.0, 29.5, 29.8, 30.0, 30.5, 30.8, 31.0, 31.5, 31.8, 32.0, 32.5, 32.8, 33.0, 33.5, 33.8, 34.0, 34.5, 34.8, 35.0, 35.5, 35.8, 36.0, 36.5, 36.8, 37.0, 37.5, 37.8, 38.0, 38.5, 38.8, 39.0, 39.5, 39.8, 40.0, 40.5, 40.8, 41.0, 41.5, 41.8, 42.0, 42.5, 42.8, 43.0, 43.5, 43.8, 44.0, 44.5, 44.8, 45.0, 45.5, 45.8, 46.0, 46.5, 46.8, 47.0, 47.5, 47.8, 48.0, 48.5, 48.8, 49.0, 49.5, 49.8, 50.0, 50.5, 50.8, 51.0, 51.5, 51.8, 52.0, 52.5, 52.8, 53.0, 53.5, 53.8, 54.0, 54.5, 54.8, 55.0, 55.5, 55.8, 56.0, 56.5, 56.8, 57.0, 57.5, 57.8, 58.0, 58.5, 58.8, 59.0, 59.5, 59.8, 60.0, 60.5, 60.8, 61.0, 61.5, 61.8, 62.0, 62.5, 62.8, 63.0, 63.5, 63.8, 64.0, 64.5, 64.8, 65.0, 65.5, 65.8, 66.0, 66.5, 66.8, 67.0, 67.5, 67.8, 68.0, 68.5, 68.8, 69.0, 69.5, 69.8, 70.0, 70.5, 70.8, 71.0, 71.5, 71.8, 72.0, 72.5, 72.8, 73.0, 73.5, 73.8, 74.0, 74.5, 74.8, 75.0, 75.5, 75.8, 76.0, 76.5, 76.8, 77.0, 77.5, 77.8, 78.0, 78.5, 78.8, 79.0, 79.5, 79.8, 80.0, 80.5, 80.8, 81.0, 81.5, 81.8, 82.0, 82.5, 82.8, 83.0, 83.5, 83.8, 84.0, 84.5, 84.8, 85.0, 85.5, 85.8, 86.0, 86.5, 86.8, 87.0, 87.5, 87.8, 88.0, 88.5, 88.8, 89.0, 89.5, 89.8, 90.0, 90.5, 90.8, 91.0, 91.5, 91.8, 92.0, 92.5, 92.8, 93.0, 93.5, 93.8, 94.0, 94.5, 94.8, 95.0, 95.5, 95.8, 96.0, 96.5, 96.8, 97.0, 97.5, 97.8, 98.0, 98.5, 98.8, 99.0, 99.5, 100.0, 100.5, 100.8, 101.0, 101.5, 101.8, 102.0, 102.5, 102.8, 103.0, 103.5, 103.8, 104.0, 104.5, 104.8, 105.0, 105.5, 105.8, 106.0, 106.5, 106.8, 107.0, 107.5, 107.8, 108.0, 108.5, 108.8, 109.0, 109.5, 109.8, 110.0, 110.5, 110.8, 111.0, 111.5, 111.8, 112.0, 112.5, 112.8, 113.0, 113.5, 113.8, 114.0, 114.5, 114.8, 115.0, 115.5, 115.8, 116.0, 116.5, 116.8, 117.0, 117.5, 117.8, 118.0, 118.5, 118.8, 119.0, 119.5, 119.8, 120.0, 120.5, 120.8, 121.0, 121.5, 121.8, 122.0, 122.5, 122.8, 123.0, 123.5, 123.8, 124.0, 124.5, 124.8, 125.0, 125.5, 125.8, 126.0, 126.5, 126.8, 127.0, 127.5, 127.8, 128.0, 128.5, 128.8, 129.0, 129.5, 129.8, 130.0, 130.5, 130.8, 131.0, 131.5, 131.8, 132.0, 132.5, 132.8, 133.0, 133.5, 133.8, 134.0, 134.5, 134.8, 135.0, 135.5, 135.8, 136.0, 136.5, 136.8, 137.0, 137.5, 137.8, 138.0, 138.5, 138.8, 139.0, 139.5, 139.8, 140.0, 140.5, 140.8, 141.0, 141.5, 141.8, 142.0, 142.5, 142.8, 143.0, 143.5, 143.8, 144.0, 144.5, 144.8, 145.0, 145.5, 145.8, 146.0, 146.5, 146.8, 147.0, 147.5, 147.8, 148.0, 148.5, 148.8, 149.0, 149.5, 149.8, 150.0, 150.5, 150.8, 151.0, 151.5, 151.8, 152.0, 152.5, 152.8, 153.0, 153.5, 153.8, 154.0, 154.5, 154.8, 155.0, 155.5, 155.8, 156.0, 156.5, 156.8, 157.0, 157.5, 157.8, 158.0, 158.5, 158.8, 159.0, 159.5, 159.8, 160.0, 160.5, 160.8, 161.0, 161.5, 161.8, 162.0, 162.5, 162.8, 163.0, 163.5, 163.8, 164.0, 164.5, 164.8, 165.0, 165.5, 165.8, 166.0, 166.5, 166.8, 167.0, 167.5, 167.8, 168.0, 168.5, 168.8, 169.0, 169.5, 169.8, 170.0, 170.5, 170.8, 171.0, 171.5, 171.8, 172.0, 172.5, 172.8, 173.0, 173.5, 173.8, 174.0, 174.5, 174.8, 175.0, 175.5, 175.8, 176.0, 176.5, 176.8, 177.0, 177.5, 177.8, 178.0, 178.5, 178.8, 179.0, 179.5, 179.8, 180.0, 180.5, 180.8, 181.0, 181.5, 181.8, 182.0, 182.5, 182.8, 183.0, 183.5, 183.8, 184.0, 184.5, 184.8, 185.0, 185.5, 185.8, 186.0, 186.5, 186.8, 187.0, 187.5, 187.8, 188.0, 188.5, 188.8, 189.0, 189.5, 189.8, 190.0, 190.5, 190.8, 191.0, 191.5, 191.8, 192.0, 192.5, 192.8, 193.0, 193.5, 193.8, 194.0, 194.5, 194.8, 195.0, 195.5, 195.8, 196.0, 196.5, 196.8, 197.0, 197.5, 197.8, 198.0, 198.5, 198.8, 199.0, 199.5, 200.0, 200.5, 200.8, 201.0, 201.5, 201.8, 202.0, 202.5, 202.8, 203.0, 203.5, 203.8, 204.0, 204.5, 204.8, 205.0, 205.5, 205.8, 206.0, 206.5, 206.8, 207.0, 207.5, 207.8, 208.0, 208.5, 208.8, 209.0, 209.5, 209.8, 210.0, 210.5, 210.8, 211.0, 211.5, 211.8, 212.0, 212.5, 212.8, 213.0, 213.5, 213.8, 214.0, 214.5, 214.8, 215.0, 215.5, 215.8, 216.0, 216.5, 216.8, 217.0, 217.5, 217.8, 218.0, 218.5, 218.8, 219.0, 219.5, 219.8, 220.0, 220.5, 220.8, 221.0, 221.5, 221.8, 222.0, 222.5, 222.8, 223.0, 223.5, 223.8, 224.0, 224.5, 224.8, 225.0, 225.5, 225.8, 226.0, 226.5, 226.8, 227.0, 227.5, 227.8, 228.0, 228.5, 228.8, 229.0, 229.5, 229.8, 230.0, 230.5, 230.8, 231.0, 231.5, 231.8, 232.0, 232.5, 232.8, 233.0, 233.5, 233.8, 234.0, 234.5, 234.8, 235.0, 235.5, 235.8, 236.0, 236.5, 236.8, 237.0, 237.5, 237.8, 238.0, 238.5, 238.8, 239.0, 239.5, 239.8, 240.0, 240.5, 240.8, 241.0, 241.5, 241.8, 242.0, 242.5, 242.8, 243.0, 243.5, 243.8, 244.0, 244.5, 244.8, 245.0, 245.5, 245.8, 246.0, 246.5, 246.8, 247.0, 247.5, 247.8, 248.0, 248.5, 248.8, 249.0, 249.5, 249.8, 250.0, 250.5, 250.8, 251.0, 251.5, 251.8, 252.0, 252.5, 252.8, 253.0, 253.5, 253.8, 254.0, 254.5, 254.8, 255.0, 255.5, 255.8, 256.0, 256.5, 256.8, 257.0, 257.5, 257.8, 258.0, 258.5, 258.8, 259.0, 259.5, 259.8, 260.0, 260.5, 260.8, 261.0, 261.5, 261.8, 262.0, 262.5, 262.8, 263.0, 263.5, 263.8, 264.0, 264.5, 264.8, 265.0, 265.5, 265.8, 266.0, 266.5, 266.8, 267.0, 267.5, 267.8, 268.0, 268.5, 268.8, 269.0, 269.5, 269.8, 270.0, 270.5, 270.8, 271.0, 271.5, 271.8, 272.0, 272.5, 272.8, 273.0, 273.5, 273.8, 274.0, 274.5, 274.8, 275.0, 275.5, 275.8, 276.0, 276.5, 276.8, 277.0, 277.5, 277.8, 278.0, 278.5, 278.8, 279.0, 279.5, 279.8, 280.0, 280.5, 280.8, 281.0, 281.5, 281.8, 282.0, 282.5, 282.8, 283.0, 283.5, 283.8, 284.0, 284.5, 284.8, 285.0, 285.5, 285.8, 286.0, 286.5, 286.8, 287.0, 287.5, 287.8, 288.0, 288.5, 288.8, 289.0, 289.5, 289.8, 290.0, 290.5, 290.8, 291.0, 291.5, 291.8, 292.0, 292.5, 292.8, 293.0, 293.5, 293.8, 294.0, 294.5, 294.8, 295.0, 295.5, 295.8, 296.0, 296.5, 296.8, 297.0, 297.5, 297.8, 298.0, 298.5, 298.8, 299.0, 299.5, 300.0, 300.5, 300.8, 301.0, 301.5, 301.8, 302.0, 302.5, 302.8, 303.0, 303.5, 303.8, 304.0, 304.5, 304.8, 305.0, 305.5, 305.8, 306.0, 306.5, 306.8, 307.0, 307.5, 307.8, 308.0, 308.5, 308.8, 309.0, 309.5, 309.8, 310.0, 310.5, 310.8, 311.0, 311.5, 311.8, 312.0, 312.5, 312.8, 313.0, 313.5, 313.8, 314.0, 314.5, 314.8, 315.0, 315.5, 315.8, 316.0, 316.5, 316.8, 317.0, 317.5, 317.8, 318.0, 318.5, 318.8, 319.0, 319.5, 319.8, 320.0, 320.5, 320.8, 321.0, 321.5, 321.8, 322.0, 322.5, 322.8, 323.0, 323.5, 323.8, 324.0, 324.5, 324.8, 325.0, 325.5, 325.8, 326.0, 326.5, 326.8, 327.0, 327.5, 327.8, 328.0, 328.5, 328.8, 329.0, 329.5, 329.8, 330.0, 330.5, 330.8, 331.0, 331.5, 331.8, 332.0, 332.5, 332.8, 333.0, 333.5, 333.8, 334.0, 334.5, 334.8, 335.0, 335.5, 335.8, 336.0, 336.5, 336.8, 337.0, 337.5, 337.8, 338.0, 338.5, 338.8, 339.0, 339.5, 339.8, 340.0, 340.5, 340.8, 341.0, 341.5, 341.8, 342.0, 342.5, 342.8, 343.0, 343.5, 343.8, 344.0, 344.5, 344.8, 345.0, 345.5, 345.8, 346.0, 346.5, 346.8, 347.0, 347.5, 347.8, 348.0, 348.5, 348.8, 349.0, 349.5, 349.8, 350.0, 350.5, 350.8, 351.0, 351.5, 351.8, 352.0, 352.5, 352.8, 353.0, 353.5, 353.8, 354.0, 354.5, 354.8, 355.0, 355.5, 355.8, 356.0, 356.5, 356.8, 357.0, 357.5, 357.8, 358.0, 358.5, 358.8, 359.0, 359.5, 359.8, 360.0, 360.5, 360.8, 361.0, 361.5, 361.8, 362.0, 362.5, 362.8, 363.0, 363.5, 363.8, 364.0, 364.5, 364.8, 365.0, 365.5, 365.8, 366.0, 366.5, 366.8, 367.0, 367.5, 367.8, 368.0, 368.5, 368.8, 369.0, 369.5, 369.8, 370.0, 370.5, 370.8, 371.0, 371.5, 371.8, 372.0, 372.5, 372.8, 373.0, 373.5, 373.8, 374.0, 374.5, 374.8, 375.0, 375.5, 375.8, 376.0, 376.5, 376.8, 377.0, 377.5, 377.8, 378.0, 378.5, 378.8, 379.0, 379.5, 379.8, 380.0, 380.5, 380.8, 381.0, 381.5, 381.8, 382.0, 382.5, 382.8, 383.0, 383.5, 383.8, 384.0, 384.5, 384.8, 385.0, 385.5, 385.8, 386.0, 386.5, 386.8, 387.0, 387.5, 387.8, 388.0, 388.5, 388.8, 389.0, 389.5, 389.8, 390.0, 390.5, 390.8, 391.0, 391.5, 391.8, 392.0, 392.5, 392.8, 393.0, 393.5, 393.8, 394.0, 394.5, 394.8, 395.0, 395.5, 395.8, 396.0, 396.5, 396.8, 397.0, 397.5, 397.8, 398.0, 398.5, 398.8, 399.0, 399.5, 400.0, 400.5, 400.8, 401.0, 401.5, 401.8, 402.0, 402.5, 402.8, 403.0, 403.5, 403.8, 404.0, 404.5, 404.8, 405.0, 405.5, 405.8, 406.0, 406.5, 406.8, 407.0, 407.5, 407.8, 408.0, 408.5, 408.8, 409.0, 409.5, 409.8, 410.0, 410.5, 410.8, 411.0, 411.5, 411.8, 412.0, 412.5, 412.8, 413.0, 413.5, 413.8, 414.0, 414.5, 414.8, 415.0, 415.5, 415.8, 416.0, 416.5, 416.8, 417.0, 417.5, 417.8, 418.0, 418.5, 418.8, 419.0, 419.5, 419.8, 420.0, 420.5, 420.8, 421.0, 421.5, 421.8, 422.0, 422.5, 422.8, 423.0, 423.5, 423.8, 424.0, 424.5, 424.8, 425.0, 425.5, 425.8, 426.0, 426.5, 426.8, 427.0, 427.5, 427.8, 428.0, 428.5, 428.8, 429.0, 429.5, 429.8, 430.0, 430.5, 430.8, 431.0, 431.5, 431.8, 432.0, 432.5, 432.8, 433.0, 433.5, 433.8, 434.0, 434.5, 434.8, 435.0, 435.5, 435.8, 436.0, 436.5, 436.8, 437.0, 437.5, 437.8, 438.0, 438.5, 438.8, 439.0, 439.5, 439.8, 440.0, 440.5, 440.8, 441.0, 441.5, 441.8, 442.0, 442.5, 442.8, 443.0, 443.5, 443.8, 444.0, 444.5, 444.8, 445.0, 445.5, 445.8, 446.0, 446.5, 446.8, 447.0, 447.5, 447.8, 448.0, 448.5, 448.8, 449.0, 449.5, 449.8, 450.0, 450.5, 450.8, 451.0, 451.5, 451.8, 452.0, 452.5, 452.8, 453.0, 453.5, 453.8, 454.0, 454.5, 454.8, 455.0, 455.5, 455.8, 456.0, 456.5, 456.8, 457.0, 457.5, 457.8, 458.0, 458.5, 458.8, 459.0, 459.5, 459.8, 460.0, 460.5, 460.8, 461.0, 461.5, 461.8, 462.0, 462.5, 462.8, 463.0, 463.5, 463.8, 464.0, 464.5, 464.8, 465.0, 465.5, 465.8, 466.0, 466.5, 466.8, 467.0, 467.5, 467.8, 468.0, 468.5, 468.8, 469.0, 469.5, 469.8, 470.0, 470.5, 470.8, 471.0, 471.5, 471.8, 472.0, 472.5, 472.8, 473.0, 473.5, 473.8, 474.0, 474.5, 474.8, 475.0, 475.5, 475.8, 476.0, 476.5, 476.8, 477.0, 477.5, 477.8, 478.0, 478.5, 478.8, 479.0, 479.5, 479.8, 480.0, 480.5, 480.8, 481.0, 481.5, 481.8, 482.0, 482.5, 482.8, 483.0, 483.5, 483.8, 484.0, 484.5, 484.8, 485.0, 485.5, 485.8, 486.0, 486.5, 486.8, 487.0, 487.5, 487.8, 488.0, 488.5, 488.8, 489.0, 489.5, 489.8, 490.0, 490.5, 490.8, 491.0, 491.5, 491.8, 492.0, 492.5, 492.8, 493.0, 493.5, 493.8, 494.0, 494.5, 494.8, 495.0, 495.5, 495.8, 496.0, 496.5, 496.8, 497.0, 497.5, 497.8, 498.0, 498.5, 498.8, 499.0, 499.5, 500.0, 500.5, 500.8, 501.0, 501.5, 501.8, 502.0, 502.5, 502.8, 503.0, 503.5, 503.8, 504.0, 504.5, 504.8, 505.0, 505.5, 505.8, 506.0, 506.5, 506.8, 507.0, 507.5, 507.8, 508.0, 508.5, 508.8, 509.0, 509.5, 509.8, 510.0, 510.5, 510.8, 511.0, 511.5, 511.8, 512.0, 512.5, 512.8, 513.0, 513.5, 513.8, 514.0, 514.5, 514.8, 515.0, 515.5, 515.8, 516.0, 516.5, 516.8, 517.0, 517.5, 517.8, 518.0, 518.5, 518.8, 519.0, 519.5, 519.8, 520.0, 520.5, 520.8, 521.0, 521.5, 521.8, 522.0, 522.5, 522.8, 523.0, 523.5, 523.8, 524.0, 524.5, 524.8, 525.0, 525.5, 525.8, 526.0, 526.5, 526.8, 527.0, 527.5, 527.8, 528.0, 528.5, 528.8, 529.0, 529.5, 529.8, 530.0, 530.5, 530.8, 531.0, 531.5, 531.8, 532.0, 532.5, 532.8, 533.0, 533.5, 533.8, 534.0, 534.5, 534.8, 535.0, 535.5, 535.8, 536.0, 536.5, 536.8, 537.0, 537.5, 537.8, 538.0, 538.5, 538.8, 539.0, 539.5, 539.8, 540.0, 540.5, 540.8, 541.0, 541.5, 541.8, 542.0, 542.5, 542.8, 543.0, 543.5, 543.8, 544.0, 544.5, 544.8, 545.0, 545.5, 545.8, 546.0, 546.5, 546.8, 547.0, 547.5, 547.8, 548.0, 548.5, 548.8, 549.0, 549.5, 549.8, 550.0, 550.5, 550.8, 551.0, 551.5, 551.8, 552.0, 552.5, 552.8, 553.0, 553.5, 553.8, 554.0, 554.5, 554.8, 555.0, 555.5, 555.8, 556.0, 556.5, 556.8, 557.0, 557.5, 557.8, 558.0, 558.5, 558.8, 559.0, 559.5, 559.8, 560.0, 560.5, 560.8, 561.0, 561.5,
```



```
In [8]: import numpy as np
```

```
In [9]: bream_length_mean=np.mean(bream_length)
bream_weight_mean=np.mean(bream_weight)
```

```
In [10]: print(bream_length_mean,bream_weight_mean)
```

```
33.10857142857143 617.8285714285714
```

```
In [12]: print('도미의 길이 : %.2fcm, 도미의 무게 : %.2fg' %(bream_length_mean,bream_weight_m
도미의 길이 : 33.11cm, 도미의 무게 : 617.83g
```

```
In [13]: np.sum((bream_length-bream_length_mean)*(bream_weight-bream_weight_mean))/len(bream_
```

```
Out[13]: 752.2871836734696
```

```
In [14]: np.sum((bream_length-bream_length_mean)*(bream_weight-bream_weight_mean))/len(bream_
```

```
Out[14]: 752.2871836734696
```

```
In [16]: #help(np.cov)
```

```
In [17]: np.cov(bream_length,bream_weight)
```

```
Out[17]: array([[1.53031597e+01, 7.74413277e+02],
.....: [7.74413277e+02, 4.37670286e+04]])
```

```
In [18]: 7.74413277e+02
```

```
Out[18]: 774.413277
```

```
In [20]: np.sum((bream_length-bream_length_mean)*(bream_weight-bream_weight_mean))/(len(bream_
```

Out[20]: 774.4132773109245

상관계수

공분산이 $Cov(x, y) = \frac{\sum_{i=1}^n (x_i - \bar{x})(y_i - \bar{y})}{n}$ 일 때,

상관계수는 $Corr(x, y) = \frac{Cov(x, y)}{\sqrt{\frac{\sum_{i=1}^n (x_i - \bar{x})^2}{n} \times \frac{\sum_{i=1}^n (y_i - \bar{y})^2}{n}}}$

이를 정리하면

$$Corr(x, y) = \frac{Cov(x, y)}{S.D(x) \times S.D(y)} \quad (S.D(x) : x \text{의 표준편차}, S.D(y) : y \text{의 표준편차})$$

$$(\text{상관계수}) = \frac{(\text{공분산})}{(X \text{의 표준편차}) \times (Y \text{의 표준편차})}$$

In [24]: `np.sqrt(np.std(bream_length)*np.std(bream_weight))`

Out[24]: 28.195998535286826

In [23]: `774.4132773109245/np.sqrt(np.std(bream_length)*np.std(bream_weight))`

Out[23]: 27.465360956866242

In [27]: `774.4132773109245/(np.std(bream_length)*np.std(bream_weight))`

Out[27]: 0.9740871890915229

In [34]: `774.4132773109245/np.sqrt(np.sum((bream_length-bream_length_mean)**2)/(len(bream_length)))`

Out[34]: 0.9462561265460507

In [25]: `#help(np.corrcoef)`

In [26]: `np.corrcoef(bream_length,bream_weight)`

Out[26]: `array([[1., 0.94625613],
..... [0.94625613, 1.]])`

In [37]: `#!pip install nbconvert[webpdf]`

In []: