$V_{AA} = 1020 - 1023$
$\Rightarrow V_{ref} = V_{in} = 5V$

What is the maximum voltage, with respect to ground, that can be applied to any pin (hint: there's an Electrical Characteristics chapter in the ATMega4809 Datasheet)

$V_{DD} + 0.5V$

With the choice of R1=10k[?], calculate what the result from analogReadwill be making appropriate assumptions on the resistances of the photoresistor.

$$Result = 1023 \times \left(\frac{V_{in} = 3.37V}{V_{ref} = 5V}\right) = 690 \pm 2$$
$V = 3.37V$
$i = 3.37 \times 10^{-4} A$

Leaving your robot connected to the USB cable, position your robot in the floor space where your robot will navigate

Average: 417 - 418

```
19:50:25.925 -> Value on A0: 413
19:50:25.925 ->
19:50:26.367 -> Value on A0: 412
19:50:26.367 ->
19:50:26.862 -> Value on A0: 412
19:50:26.862 ->
19:50:27.356 -> Value on A0: 412
19:50:27.394 ->
19:50:27.852 -> Value on A0: 411
19:50:27.885 ->
19:50:28.345 -> Value on A0: 411
19:50:28.378 ->
19:50:28.864 -> Value on A0: 412
19:50:28.864 ->
19:50:29.364 -> Value on A0: 414
19:50:29.364 ->
19:50:29.864 -> Value on A0: 421
19:50:29.864 ->
19:50:30.366 -> Value on A0: 424
19:50:30.366 ->
19:50:30.869 -> Value on A0: 424
19:50:30.869 ->
19:50:31.364 -> Value on A0: 422
19:50:31.364 ->
19:50:31.862 -> Value on A0: 423
19:50:31.862 ->
19:50:32.356 -> Value on A0: 423
19:50:32.356 ->
19:50:32.856 -> Value on A0: 423
19:50:32.856 ->
19:50:33.333 -> Value on A0: 424
19:50:33.371 ->
19:50:33.852 -> Value on A0: 421
19:50:33.852 ->
19:50:34.356 -> Value on A0: 419
19:50:34.356 ->
```

Under “normal, “ i.e., not too bright conditions, take note of the output of A0 from the Serial Monitor.

```
19:55:16.673 ->
19:55:17.137 -> Value on A0: 390
19:55:17.175 ->
19:55:17.641 -> Value on A0: 390
19:55:17.641 ->
19:55:18.139 -> Value on A0: 389
19:55:18.139 ->
19:55:18.646 -> Value on A0: 391
19:55:18.646 ->
19:55:19.146 -> Value on A0: 392
19:55:19.146 ->
19:55:19.638 -> Value on A0: 392
19:55:19.638 ->
19:55:20.131 -> Value on A0: 391
19:55:20.168 ->
19:55:20.624 -> Value on A0: 391
19:55:20.662 ->
19:55:21.120 -> Value on A0: 391
19:55:21.154 ->
19:55:21.614 -> Value on A0: 390
19:55:21.651 ->
19:55:22.124 -> Value on A0: 391
19:55:22.162 ->
19:55:22.625 -> Value on A0: 391
19:55:22.662 ->
19:55:23.132 -> Value on A0: 393
19:55:23.132 ->
19:55:23.637 -> Value on A0: 393
19:55:23.637 ->
19:55:24.135 -> Value on A0: 393
19:55:24.135 ->
19:55:24.638 -> Value on A0: 391
19:55:24.638 ->
19:55:25.113 -> Value on A0: 392
19:55:25.150 ->
19:55:25.618 -> Value on A0: 390
19:55:25.656 ->
19:55:26.119 -> Value on A0: 391
19:55:26.119 ->
19:55:26.626 -> Value on A0: 391
19:55:26.626 ->
19:55:27.099 -> Value on A0: 391
19:55:27.132 ->
19:55:27.630 -> Value on A0: 392
19:55:27.630 ->
19:55:28.099 -> Value on A0: 393
19:55:28.134 ->
19:55:28.630 -> Value on A0: 394
19:55:28.630 ->
19:55:29.126 -> Value on A0: 392
19:55:29.126 ->
19:55:29.621 -> Value on A0: 393
19:55:29.621 ->
19:55:30.124 -> Value on A0: 392
19:55:30.124 ->
19:55:30.596 -> Value on A0: 390
19:55:30.629 ->
19:55:31.119 -> Value on A0: 392
19:55:31.119 ->
19:55:31.622 -> Value on A0: 392
19:55:31.622 ->
19:55:32.091 -> Value on A0: 394
```

```
19:54:30.747 -> Value on A0: 328
19:54:30.780 ->
19:54:31.267 -> Value on A0: 330
19:54:31.267 ->
19:54:31.761 -> Value on A0: 332
19:54:31.761 ->
19:54:32.267 -> Value on A0: 333
19:54:32.267 ->
19:54:32.766 -> Value on A0: 335
19:54:32.766 ->
19:54:33.233 -> Value on A0: 334
19:54:33.271 ->
19:54:33.754 -> Value on A0: 337
19:54:33.754 ->
19:54:34.234 -> Value on A0: 337
19:54:34.267 ->
19:54:34.735 -> Value on A0: 338
19:54:34.773 ->
19:54:35.240 -> Value on A0: 339
19:54:35.274 ->
19:54:35.743 -> Value on A0: 341
19:54:35.778 ->
19:54:36.240 -> Value on A0: 342
19:54:36.274 ->
19:54:36.744 -> Value on A0: 342
19:54:36.744 ->
19:54:37.247 -> Value on A0: 344
19:54:37.247 ->
19:54:37.740 -> Value on A0: 344
19:54:37.740 ->
19:54:38.254 -> Value on A0: 346
19:54:38.254 ->
19:54:38.724 -> Value on A0: 348
19:54:38.760 ->
19:54:39.217 -> Value on A0: 350
19:54:39.255 ->
19:54:39.719 -> Value on A0: 352
19:54:39.755 ->
19:54:40.226 -> Value on A0: 353
19:54:40.264 ->
19:54:40.744 -> Value on A0: 352
19:54:40.744 ->
19:54:41.231 -> Value on A0: 351
19:54:41.231 ->
19:54:41.710 -> Value on A0: 353
19:54:41.747 ->
19:54:42.238 -> Value on A0: 355
19:54:42.238 ->
19:54:42.719 -> Value on A0: 356
19:54:42.754 ->
19:54:43.239 -> Value on A0: 357
19:54:43.239 ->
19:54:43.718 -> Value on A0: 358
19:54:43.751 ->
19:54:44.223 -> Value on A0: 360
19:54:44.223 ->
19:54:44.723 -> Value on A0: 360
19:54:44.723 ->
19:54:45.230 -> Value on A0: 358
19:54:45.230 ->
19:54:45.725 -> Value on A0: 361
19:54:45.725 ->
```

```
19:54:15.798 -> Value on A0: 287
19:54:15.834 ->
19:54:16.312 -> Value on A0: 288
19:54:16.312 ->
19:54:16.790 -> Value on A0: 289
19:54:16.828 ->
19:54:17.293 -> Value on A0: 290
19:54:17.330 ->
19:54:17.789 -> Value on A0: 291
19:54:17.823 ->
19:54:18.302 -> Value on A0: 294
19:54:18.302 ->
19:54:18.773 -> Value on A0: 295
19:54:18.810 ->
19:54:19.280 -> Value on A0: 298
19:54:19.318 ->
19:54:19.781 -> Value on A0: 297
19:54:19.820 ->
19:54:20.281 -> Value on A0: 301
19:54:20.318 ->
19:54:20.781 -> Value on A0: 302
19:54:20.814 ->
19:54:21.295 -> Value on A0: 302
19:54:21.295 ->
19:54:21.767 -> Value on A0: 304
19:54:21.800 ->
19:54:22.297 -> Value on A0: 308
19:54:22.297 ->
19:54:22.762 -> Value on A0: 307
19:54:22.798 ->
19:54:23.260 -> Value on A0: 307
19:54:23.296 ->
19:54:23.768 -> Value on A0: 309
19:54:23.803 ->
19:54:24.267 -> Value on A0: 310
19:54:24.304 ->
19:54:24.756 -> Value on A0: 312
19:54:24.790 ->
19:54:25.292 -> Value on A0: 315
19:54:25.292 ->
19:54:25.752 -> Value on A0: 316
19:54:25.789 ->
19:54:26.254 -> Value on A0: 317
19:54:26.290 ->
19:54:26.749 -> Value on A0: 317
19:54:26.781 ->
19:54:27.268 -> Value on A0: 318
19:54:27.268 ->
19:54:27.764 -> Value on A0: 321
19:54:27.799 ->
19:54:28.256 -> Value on A0: 322
19:54:28.292 ->
19:54:28.751 -> Value on A0: 324
19:54:28.789 ->
19:54:29.254 -> Value on A0: 324
19:54:29.290 ->
19:54:29.753 -> Value on A0: 326
19:54:29.791 ->
19:54:30.246 -> Value on A0: 327
19:54:30.283 ->
```

Average: 341

---

$$\text{Illum} = 100 \frac{\text{lumen}}{\text{m}^2} = 100 \text{ lux}$$

$$\text{Area} = 4.29 \times 10^{-3} \text{ m} \times 5.08 \times 10^{-3} \text{ m} = 2.18 \times 10^{-5} \text{ m}^2$$

$$\eta = 90 \frac{\text{lumen}}{\text{W}}$$

$$\lambda_{avg} = 600 \times 10^{-9} \text{ m}$$

$$E = hc/\lambda_{avg} = 3.313 \times 10^{-19} \text{ J}$$

$$\frac{100 \frac{\text{lumen}}{\text{m}^2} \times 2.18 \times 10^{-5} \text{ m}^2}{90 \frac{\text{lumen}}{\text{W}}} = 2.42 \times 10^{-5} \text{ W} = 2.42 \times 10^{-5} \frac{\text{J}}{\text{s}}$$

$$\frac{2.42 \times 10^{-5} \text{ W}}{3.313 \times 10^{-19} \text{ J}} = 7.311 \times 10^{13} \frac{\text{photons}}{\text{sec}}$$

Using your flashlight, illuminate the CdS photoresistor by holding the light a distance of maybe 30-60 cm (the distance doesn't really matter too much: the idea is that your robot will sense your flashlight as being the bright light source as compared to the background), and take note of the output of A0 from the Serial Monitor.

```
20:03:02.490 -> Value on A0: 750
20:03:02.525 ->
20:03:03.011 -> Value on A0: 745
20:03:03.011 ->
20:03:03.500 -> Value on A0: 748
20:03:03.500 ->
20:03:03.989 -> Value on A0: 746
20:03:04.023 ->
20:03:04.490 -> Value on A0: 746
20:03:04.523 ->
20:03:04.989 -> Value on A0: 746
20:03:05.022 ->
20:03:05.479 -> Value on A0: 745
20:03:05.516 ->
20:03:05.973 -> Value on A0: 746
20:03:06.007 ->
20:03:06.489 -> Value on A0: 744
20:03:06.524 ->
20:03:06.988 -> Value on A0: 747
20:03:07.025 ->
20:03:07.477 -> Value on A0: 746
20:03:07.513 ->
20:03:08.002 -> Value on A0: 745
20:03:08.002 ->
20:03:08.498 -> Value on A0: 743
20:03:08.498 ->
20:03:08.989 -> Value on A0: 746
20:03:08.989 ->
20:03:09.478 -> Value on A0: 746
20:03:09.512 ->
20:03:09.993 -> Value on A0: 746
20:03:09.993 ->
20:03:10.473 -> Value on A0: 745
20:03:10.510 ->
20:03:10.963 -> Value on A0: 744
20:03:11.000 ->
20:03:11.488 -> Value on A0: 747
20:03:11.488 ->
20:03:11.962 -> Value on A0: 746
20:03:11.996 ->
20:03:12.493 -> Value on A0: 743
20:03:12.493 ->
20:03:12.988 -> Value on A0: 744
20:03:12.988 ->
20:03:13.471 -> Value on A0: 741
20:03:13.506 ->
20:03:13.981 -> Value on A0: 743
20:03:13.981 ->
20:03:14.476 -> Value on A0: 744
20:03:14.476 ->
20:03:14.977 -> Value on A0: 741
20:03:14.977 ->
20:03:15.479 -> Value on A0: 742
20:03:15.479 ->
20:03:15.953 -> Value on A0: 744
20:03:15.989 ->
20:03:16.453 -> Value on A0: 739
20:03:16.486 ->
20:03:16.974 -> Value on A0: 739
20:03:16.974 ->
20:03:17.470 -> Value on A0: 742
```

```
20:02:47.036 -> Value on A0: 760
20:02:47.074 ->
20:02:47.528 -> Value on A0: 761
20:02:47.566 ->
20:02:48.032 -> Value on A0: 760
20:02:48.070 ->
20:02:48.545 -> Value on A0: 760
20:02:48.545 ->
20:02:49.031 -> Value on A0: 756
20:02:49.069 ->
20:02:49.530 -> Value on A0: 756
20:02:49.564 ->
20:02:50.014 -> Value on A0: 757
20:02:50.052 ->
20:02:50.513 -> Value on A0: 756
20:02:50.549 ->
20:02:51.034 -> Value on A0: 757
20:02:51.034 ->
20:02:51.547 -> Value on A0: 756
20:02:51.547 ->
20:02:52.034 -> Value on A0: 755
20:02:52.034 ->
20:02:52.543 -> Value on A0: 756
20:02:52.543 ->
20:02:53.014 -> Value on A0: 755
20:02:53.052 ->
20:02:53.512 -> Value on A0: 754
20:02:53.550 ->
20:02:54.029 -> Value on A0: 754
20:02:54.029 ->
20:02:54.505 -> Value on A0: 754
20:02:54.543 ->
20:02:55.032 -> Value on A0: 751
20:02:55.032 ->
20:02:55.530 -> Value on A0: 750
20:02:55.530 ->
20:02:56.026 -> Value on A0: 755
20:02:56.026 ->
20:02:56.508 -> Value on A0: 752
20:02:56.542 ->
20:02:57.028 -> Value on A0: 753
20:02:57.028 ->
20:02:57.519 -> Value on A0: 752
20:02:57.519 ->
20:02:58.000 -> Value on A0: 752
20:02:58.038 ->
20:02:58.495 -> Value on A0: 750
20:02:58.528 ->
20:02:59.012 -> Value on A0: 746
20:02:59.012 ->
20:02:59.505 -> Value on A0: 749
20:02:59.540 ->
20:03:00.000 -> Value on A0: 750
20:03:00.038 ->
20:03:00.489 -> Value on A0: 749
20:03:00.527 ->
20:03:00.986 -> Value on A0: 748
20:03:01.020 ->
20:03:01.517 -> Value on A0: 752
20:03:01.517 ->
20:03:01.994 -> Value on A0: 748
```

Average: 748

$$NM_{left} = \frac{SensorReading_{left}}{SensorReading_{left} + SensorReading_{right}}$$

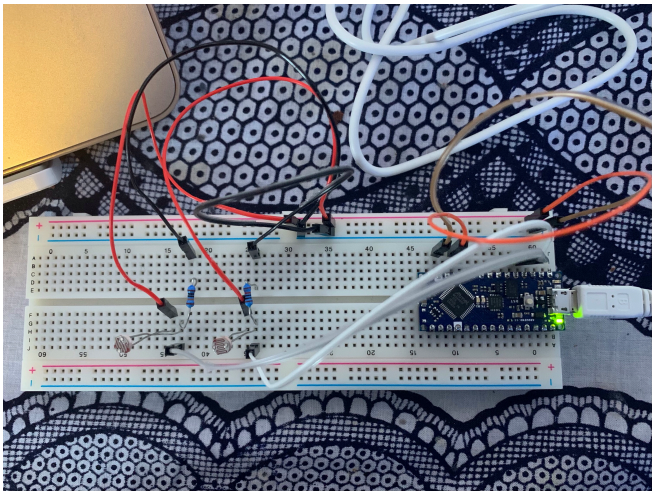
$$NM_{right} = \frac{SensorReading_{right}}{SensorReading_{right} + SensorReading_{left}}$$

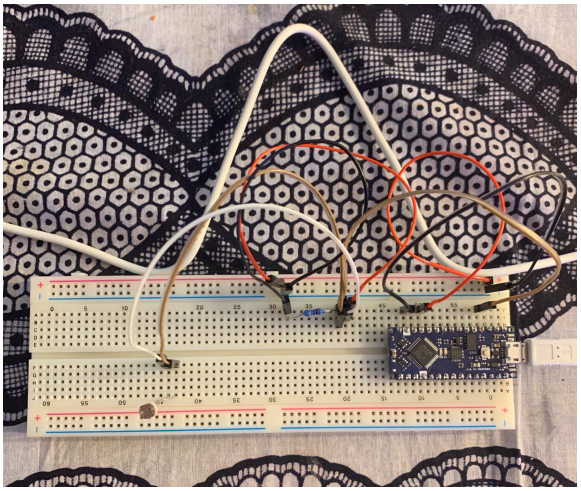
## Interpretations

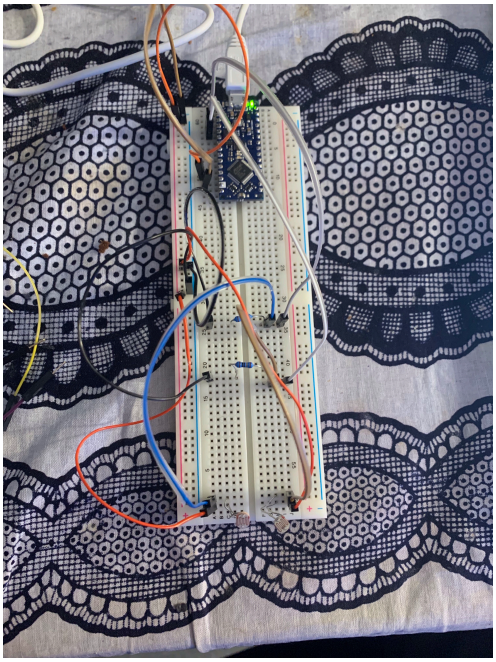
$NM_{left} = 0.25 \Rightarrow$ low brightness in left sensor

$NM_{left} = 0.50 \Rightarrow$ medium brightness in left sensor

$NM_{left} = 0.75 \Rightarrow$ high brightness in left sensor







```
15:33:02.043 ->
15:33:02.969 -> Right sensor value: 898
15:33:03.003 -> Left sensor value: 507
15:33:03.040 -> Normalized measurement Left: 0.36
15:33:03.074 -> Normalized measurement Right: 0.64
15:33:03.113 ->
15:33:04.040 -> Right sensor value: 861
15:33:04.040 -> Left sensor value: 452
15:33:04.074 -> Normalized measurement Left: 0.34
15:33:04.110 -> Normalized measurement Right: 0.66
15:33:04.145 ->
15:33:05.101 -> Right sensor value: 847
15:33:05.101 -> Left sensor value: 418
15:33:05.136 -> Normalized measurement Left: 0.33
15:33:05.174 -> Normalized measurement Right: 0.67
15:33:05.207 ->
15:33:06.129 -> Right sensor value: 811
15:33:06.164 -> Left sensor value: 343
15:33:06.201 -> Normalized measurement Left: 0.30
15:33:06.236 -> Normalized measurement Right: 0.70
15:33:06.274 ->
15:33:07.191 -> Right sensor value: 816
15:33:07.224 -> Left sensor value: 367
15:33:07.261 -> Normalized measurement Left: 0.31
15:33:07.300 -> Normalized measurement Right: 0.69
15:33:07.338 ->
15:33:08.245 -> Right sensor value: 833
15:33:08.279 -> Left sensor value: 388
15:33:08.312 -> Normalized measurement Left: 0.32
15:33:08.348 -> Normalized measurement Right: 0.68
15:33:08.382 ->
15:33:09.313 -> Right sensor value: 827
15:33:09.351 -> Left sensor value: 340
15:33:09.351 -> Normalized measurement Left: 0.29
15:33:09.384 -> Normalized measurement Right: 0.71
15:33:09.418 ->
15:33:10.382 -> Right sensor value: 833
15:33:10.382 -> Left sensor value: 359
15:33:10.415 -> Normalized measurement Left: 0.30
15:33:10.451 -> Normalized measurement Right: 0.70
15:33:10.486 ->
15:33:11.398 -> Right sensor value: 839
15:33:11.431 -> Left sensor value: 371
15:33:11.465 -> Normalized measurement Left: 0.31
15:33:11.501 -> Normalized measurement Right: 0.69
15:33:11.536 ->
15:33:12.457 -> Right sensor value: 824
15:33:12.490 -> Left sensor value: 294
15:33:12.524 -> Normalized measurement Left: 0.26
15:33:12.561 -> Normalized measurement Right: 0.74
15:33:12.599 ->
15:33:13.523 -> Right sensor value: 841
15:33:13.559 -> Left sensor value: 329
15:33:13.592 -> Normalized measurement Left: 0.28
15:33:13.629 -> Normalized measurement Right: 0.72
15:33:13.667 ->
15:33:14.586 -> Right sensor value: 855
15:33:14.623 -> Left sensor value: 386
15:33:14.623 -> Normalized measurement Left: 0.31
15:33:14.658 -> Normalized measurement Right: 0.69
15:33:14.691 ->
```

```
15:36:22.388 -> Right sensor value: 984
15:36:22.388 -> Left sensor value: 736
15:36:22.426 -> Normalized measurement Left: 0.43
15:36:22.462 -> Normalized measurement Right: 0.57
15:36:22.500 ->
15:36:23.434 -> Right sensor value: 984
15:36:23.471 -> Left sensor value: 742
15:36:23.471 -> Normalized measurement Left: 0.43
15:36:23.509 -> Normalized measurement Right: 0.57
15:36:23.544 ->
15:36:24.469 -> Right sensor value: 983
15:36:24.502 -> Left sensor value: 739
15:36:24.540 -> Normalized measurement Left: 0.43
15:36:24.575 -> Normalized measurement Right: 0.57
15:36:24.609 ->
15:36:25.529 -> Right sensor value: 983
15:36:25.567 -> Left sensor value: 740
15:36:25.600 -> Normalized measurement Left: 0.43
15:36:25.633 -> Normalized measurement Right: 0.57
15:36:25.671 ->
15:36:26.614 -> Right sensor value: 983
15:36:26.614 -> Left sensor value: 738
15:36:26.649 -> Normalized measurement Left: 0.43
15:36:26.683 -> Normalized measurement Right: 0.57
15:36:26.716 ->
15:36:27.639 -> Right sensor value: 981
15:36:27.673 -> Left sensor value: 738
15:36:27.709 -> Normalized measurement Left: 0.43
15:36:27.742 -> Normalized measurement Right: 0.57
15:36:27.776 ->
15:36:28.697 -> Right sensor value: 985
15:36:28.732 -> Left sensor value: 739
15:36:28.770 -> Normalized measurement Left: 0.43
15:36:28.808 -> Normalized measurement Right: 0.57
15:36:28.841 ->
15:36:29.759 -> Right sensor value: 984
15:36:29.793 -> Left sensor value: 739
15:36:29.827 -> Normalized measurement Left: 0.43
15:36:29.861 -> Normalized measurement Right: 0.57
15:36:29.899 ->
15:36:30.825 -> Right sensor value: 983
15:36:30.825 -> Left sensor value: 738
15:36:30.858 -> Normalized measurement Left: 0.43
15:36:30.892 -> Normalized measurement Right: 0.57
15:36:30.927 ->
15:36:31.858 -> Right sensor value: 982
15:36:31.892 -> Left sensor value: 738
15:36:31.926 -> Normalized measurement Left: 0.43
15:36:31.960 -> Normalized measurement Right: 0.57
15:36:31.996 ->
15:36:32.916 -> Right sensor value: 982
15:36:32.950 -> Left sensor value: 735
15:36:32.985 -> Normalized measurement Left: 0.43
15:36:33.021 -> Normalized measurement Right: 0.57
15:36:33.056 ->
15:36:33.966 -> Right sensor value: 982
15:36:34.001 -> Left sensor value: 736
15:36:34.038 -> Normalized measurement Left: 0.43
15:36:34.072 -> Normalized measurement Right: 0.57
15:36:34.108 ->
```