

Lab #1: Practice in R

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The purpose of this lab is to get you comfortable working in R and trying a few things from the first lecture.

Simulating data:

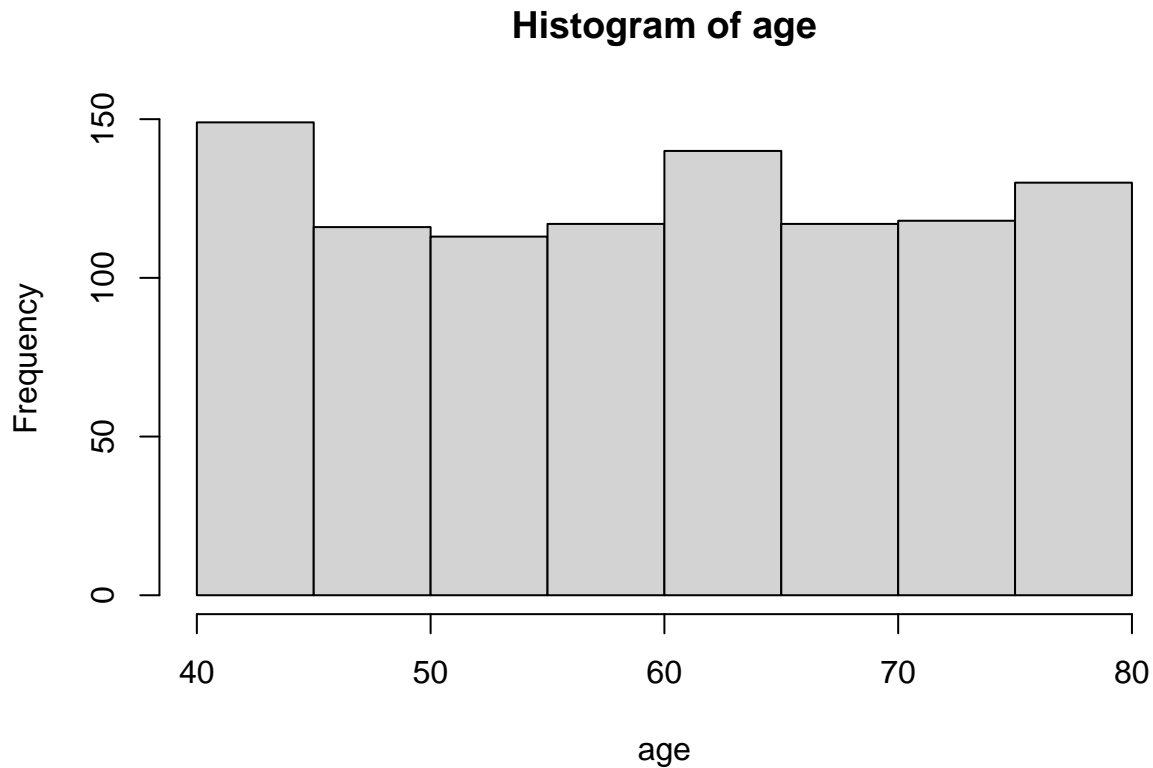
We will simulate something like the weight vs. age data from a cubic function and add some noise and then apply a few methods.

1. Write a function in R to input the value (age) and output, “noise-free” weight: $f(x) = -0.0004x^3 + 0.025x^2 + 2x + 50$

```
make_weight <- function(age) {  
  -0.0004 * age^3 + 0.025 * age^2 + 2 * age + 50  
}
```

2. Next we will simulate some values for x . Use the sample function to generate a random sample of integers between 40 and 80 of size 1000 (you will need the replace=TRUE option to make sure the numbers can be resampled otherwise you will run out of values quickly). Don't forget that you can type `?sample` to get help as to how to use the function.

```
?sample  
  
age <- sample(seq(40, 80), size=1000, replace=TRUE)  
hist(age)
```



3. Now generate a vector of the output of your function in part 1 to generate the noise-free weights for each of the 1000 individuals.

```
no_noise_weights <- make_weight(age)
no_noise_weights
```

```
##      [1] 150.4222 168.2792 144.4000 173.6182 174.7688 166.6742 171.1478 174.3008
##      [9] 173.6000 173.6000 160.9654 155.9656 159.3632 167.9144 173.6000 170.8096
##     [17] 165.2000 175.5424 170.8096 170.8096 173.6182 175.5424 167.9144 174.3008
##     [25] 172.8734 172.8104 154.1750 160.9654 169.6118 172.8734 175.9198 172.8734
##     [33] 174.7688 154.1750 166.8094 175.5424 154.1750 168.2792 154.1750 175.2062
##     [41] 174.8606 166.6742 146.4566 171.1478 174.2326 166.6742 169.6118 144.4000
##     [49] 166.8094 154.1750 174.7688 154.1750 166.8094 168.2792 162.5000 170.1536
##     [57] 171.8750 165.3568 166.8094 175.5424 175.5424 174.7688 172.8734 168.2792
##     [65] 175.8272 165.3568 174.2326 175.8272 175.9198 174.3008 173.6000 175.3000
##     [73] 169.6118 170.1536 159.3632 168.2792 174.7688 172.0552 175.7750 175.6214
##     [81] 174.8606 168.2792 175.8272 173.6182 160.9654 144.4000 175.7750 167.9144
##     [89] 175.8272 175.2062 163.9646 168.2792 175.2062 175.9198 174.2326 166.8094
##     [97] 174.3008 172.0552 175.7750 172.8104 144.4000 175.8272 166.6742 174.2326
##    [105] 154.1750 175.9198 165.2000 170.8096 148.4648 174.2326 172.8104 155.9656
##    [113] 172.8104 165.2000 175.9016 155.9656 172.8734 175.2062 169.0750 172.0552
##    [121] 171.8750 146.4566 144.4000 168.2792 165.2000 165.3568 175.7750 173.6182
##    [129] 146.4566 172.0552 170.1536 173.6182 162.5000 175.3000 172.8104 172.8104
##    [137] 172.0552 162.5000 169.0750 166.8094 159.3632 175.9198 175.2062 160.9654
##    [145] 167.9144 170.8096 174.8606 170.8096 168.2792 175.3000 170.8096 175.8272
```

```

## [153] 163.9646 166.6742 169.6118 169.0750 167.9144 146.4566 144.4000 148.4648
## [161] 159.3632 169.6118 170.1536 172.8734 152.3264 165.2000 175.9016 175.3000
## [169] 157.6958 171.8750 165.2000 175.8272 173.6000 144.4000 172.8734 175.2062
## [177] 174.2326 169.6118 169.0750 175.6214 175.8272 146.4566 157.6958 166.6742
## [185] 171.8750 175.7750 166.8094 170.8096 157.6958 155.9656 171.8750 171.8750
## [193] 159.3632 175.9016 165.2000 167.9144 169.6118 154.1750 150.4222 172.8104
## [201] 172.8104 165.3568 165.2000 155.9656 175.5424 175.3000 170.8096 175.9198
## [209] 168.2792 175.9198 172.8734 175.8272 166.8094 144.4000 175.9198 166.6742
## [217] 175.3000 163.9646 175.8272 169.0750 160.9654 173.6182 175.7750 174.3008
## [225] 150.4222 174.2326 175.5424 175.2062 170.8096 167.9144 166.6742 170.1536
## [233] 171.1478 174.3008 174.8606 157.6958 168.2792 155.9656 175.9016 159.3632
## [241] 172.8734 173.6182 170.8096 175.8272 162.5000 146.4566 148.4648 169.6118
## [249] 165.2000 167.9144 175.9198 152.3264 175.9198 166.6742 170.8096 170.1536
## [257] 144.4000 175.7750 174.3008 172.0552 175.7750 174.7688 150.4222 169.0750
## [265] 175.9016 168.2792 169.6118 169.0750 173.6182 175.8272 172.8104 160.9654
## [273] 154.1750 168.2792 174.3008 174.7688 174.3008 172.8104 162.5000 165.3568
## [281] 170.8096 175.7750 175.7750 166.8094 173.6182 150.4222 175.5424 169.6118
## [289] 170.1536 175.2062 159.3632 175.6214 159.3632 162.5000 174.2326 174.8606
## [297] 166.8094 148.4648 172.0552 174.3008 150.4222 165.3568 144.4000 166.8094
## [305] 152.3264 172.8104 174.7688 175.8272 172.8104 171.8750 159.3632 172.8104
## [313] 172.8104 172.8734 174.2326 165.2000 174.2326 172.0552 171.1478 168.2792
## [321] 175.8272 175.9016 171.8750 174.8606 175.3000 170.1536 170.8096 175.5424
## [329] 159.3632 173.6000 173.6000 167.9144 170.8096 175.2062 166.6742 155.9656
## [337] 175.9016 175.7750 175.6214 167.9144 154.1750 173.6182 173.6000 144.4000
## [345] 170.1536 165.3568 175.7750 166.8094 146.4566 165.2000 157.6958 175.5424
## [353] 175.3000 172.8734 172.8734 152.3264 160.9654 172.8734 167.9144 175.8272
## [361] 146.4566 144.4000 152.3264 175.5424 170.8096 174.8606 166.8094 165.3568
## [369] 175.5424 150.4222 169.6118 152.3264 144.4000 169.6118 165.3568 157.6958
## [377] 172.0552 175.9198 169.6118 162.5000 157.6958 174.7688 172.8734 152.3264
## [385] 146.4566 152.3264 163.9646 148.4648 175.7750 166.6742 165.3568 175.3000
## [393] 173.6182 175.6214 175.7750 155.9656 175.9016 159.3632 157.6958 174.2326
## [401] 154.1750 175.9016 175.6214 160.9654 175.6214 144.4000 154.1750 170.1536
## [409] 165.3568 175.7750 146.4566 174.8606 171.8750 152.3264 174.7688 169.6118
## [417] 172.8734 175.9198 175.9198 163.9646 172.8104 150.4222 175.7750 165.3568
## [425] 148.4648 167.9144 173.6182 169.6118 150.4222 175.7750 173.6000 173.6000
## [433] 169.0750 170.8096 175.2062 173.6000 148.4648 175.7750 174.7688 171.8750
## [441] 174.2326 148.4648 150.4222 171.8750 170.8096 144.4000 170.8096 174.2326
## [449] 173.6000 175.9016 162.5000 162.5000 154.1750 171.8750 154.1750 172.8734
## [457] 166.8094 174.3008 166.8094 162.5000 162.5000 173.6000 173.6000 170.1536
## [465] 159.3632 171.1478 175.3000 157.6958 174.7688 154.1750 162.5000 170.8096
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## [481] 165.3568 146.4566 166.8094 154.1750 167.9144 165.2000 175.9198 144.4000
## [489] 146.4566 159.3632 152.3264 175.9016 175.8272 146.4566 170.8096 175.3000
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## [505] 170.1536 174.3008 166.8094 172.0552 170.1536 172.8734 174.7688 172.8734
## [513] 175.3000 152.3264 175.9016 174.3008 144.4000 175.8272 173.6182 171.8750
## [521] 172.8734 173.6000 169.6118 175.2062 173.6182 172.8734 148.4648 172.8734
## [529] 173.6182 167.9144 175.6214 165.3568 169.0750 171.8750 175.6214 175.8272
## [537] 175.9198 165.3568 155.9656 171.1478 144.4000 150.4222 152.3264 171.8750
## [545] 173.6182 175.7750 174.3008 172.0552 170.1536 165.3568 168.2792 171.8750
## [553] 155.9656 174.2326 159.3632 174.8606 166.8094 174.3008 175.9198 163.9646
## [561] 175.6214 172.8104 175.7750 148.4648 167.9144 168.2792 174.7688 175.5424
## [569] 144.4000 175.9198 159.3632 166.6742 175.3000 169.0750 173.6000 163.9646
## [577] 175.6214 174.2326 144.4000 163.9646 175.9198 163.9646 175.5424 175.5424

```

```

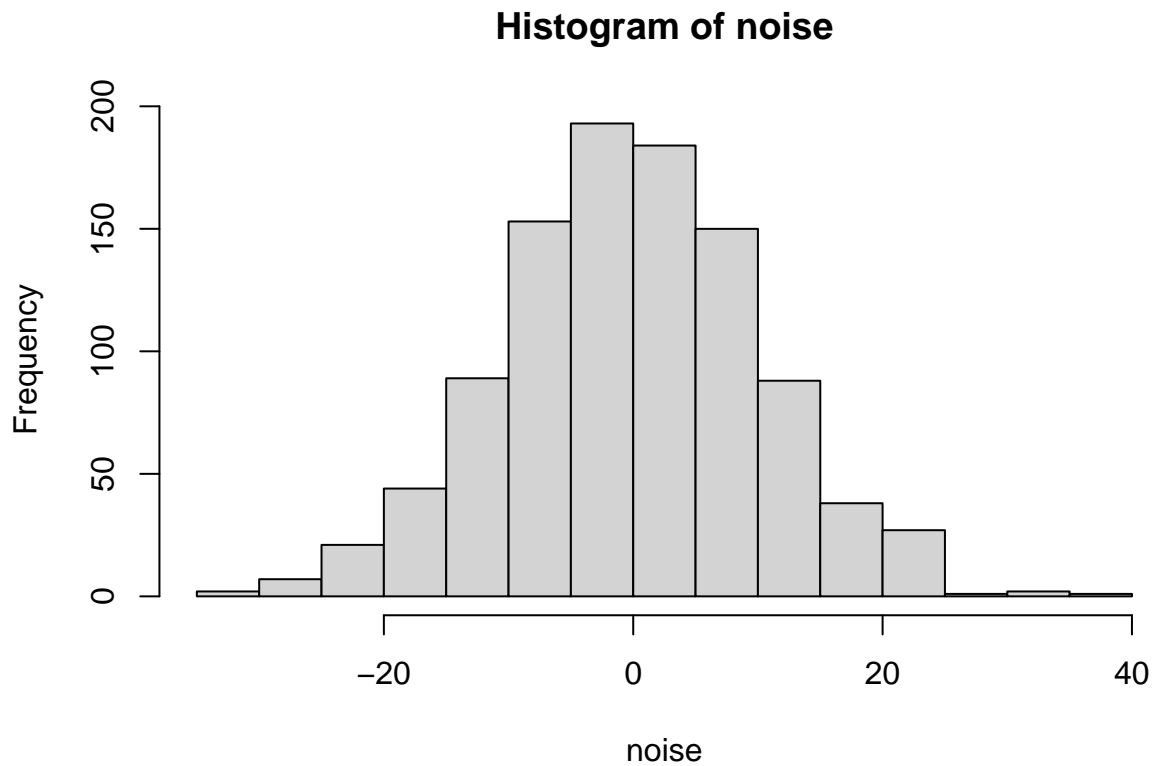
## [585] 157.6958 175.3000 152.3264 163.9646 175.6214 159.3632 146.4566 159.3632
## [593] 165.2000 165.2000 174.2326 175.9016 169.6118 174.7688 173.6182 148.4648
## [601] 144.4000 146.4566 172.0552 175.8272 152.3264 173.6182 165.2000 163.9646
## [609] 165.2000 171.1478 173.6182 165.3568 168.2792 150.4222 154.1750 174.7688
## [617] 175.5424 169.0750 174.2326 175.7750 166.8094 166.6742 154.1750 157.6958
## [625] 173.6000 175.2062 148.4648 166.8094 170.8096 166.6742 175.9016 165.3568
## [633] 172.0552 148.4648 175.8272 152.3264 175.5424 175.3000 166.6742 171.8750
## [641] 172.8734 175.3000 165.3568 148.4648 166.8094 175.2062 175.8272 160.9654
## [649] 165.3568 154.1750 160.9654 168.2792 172.0552 171.1478 173.6000 174.7688
## [657] 175.7750 167.9144 175.8272 175.8272 152.3264 174.2326 144.4000 174.2326
## [665] 165.3568 174.2326 154.1750 165.2000 174.3008 175.2062 174.2326 174.3008
## [673] 160.9654 172.0552 157.6958 163.9646 162.5000 169.0750 173.6000 154.1750
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## [689] 152.3264 152.3264 150.4222 162.5000 165.2000 146.4566 160.9654 173.6182
## [697] 146.4566 163.9646 154.1750 159.3632 168.2792 172.0552 152.3264 170.1536
## [705] 159.3632 175.5424 165.3568 163.9646 172.8104 157.6958 146.4566 159.3632
## [713] 175.3000 155.9656 152.3264 155.9656 168.2792 175.3000 146.4566 172.8734
## [721] 165.2000 157.6958 175.5424 172.8104 173.6000 174.8606 169.0750 155.9656
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## [737] 162.5000 175.2062 148.4648 155.9656 175.6214 174.2326 174.8606 174.7688
## [745] 175.2062 163.9646 175.9198 157.6958 174.7688 165.3568 171.1478 146.4566
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## [777] 174.8606 152.3264 169.6118 175.9016 160.9654 175.8272 165.3568 163.9646
## [785] 175.9016 168.2792 144.4000 159.3632 172.8104 162.5000 166.8094 171.8750
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## [841] 168.2792 172.8734 166.6742 160.9654 173.6000 174.3008 174.8606 175.9198
## [849] 175.9198 155.9656 150.4222 175.5424 175.6214 175.6214 170.8096 174.8606
## [857] 166.8094 160.9654 174.7688 159.3632 174.3008 162.5000 172.8734 172.8734
## [865] 173.6182 159.3632 165.3568 152.3264 148.4648 175.7750 170.1536 144.4000
## [873] 157.6958 172.0552 171.1478 146.4566 174.2326 171.8750 150.4222 166.6742
## [881] 162.5000 169.0750 175.5424 171.8750 152.3264 175.9016 175.3000 175.9016
## [889] 146.4566 165.2000 174.8606 174.7688 172.8734 154.1750 152.3264 172.0552
## [897] 171.1478 173.6182 173.6000 168.2792 172.8734 175.7750 174.8606 168.2792
## [905] 166.8094 160.9654 162.5000 173.6000 165.3568 172.8734 169.6118 155.9656
## [913] 170.8096 175.8272 170.1536 157.6958 169.6118 174.8606 175.2062 154.1750
## [921] 174.7688 160.9654 162.5000 160.9654 166.6742 169.0750 175.9016 165.2000
## [929] 144.4000 150.4222 168.2792 174.7688 174.8606 169.0750 166.8094 172.8734
## [937] 150.4222 159.3632 169.0750 175.3000 160.9654 174.3008 166.8094 170.1536
## [945] 165.3568 175.5424 171.1478 175.5424 160.9654 175.8272 159.3632 150.4222
## [953] 175.7750 169.6118 171.1478 172.8104 144.4000 173.6000 166.6742 175.6214
## [961] 144.4000 174.7688 165.2000 172.0552 175.9016 155.9656 166.6742 174.8606
## [969] 166.6742 175.9198 172.8734 144.4000 155.9656 175.9198 175.2062 175.7750
## [977] 175.6214 170.8096 175.2062 175.9198 166.8094 169.6118 174.7688 175.8272
## [985] 166.8094 167.9144 160.9654 172.8104 175.5424 159.3632 166.6742 172.0552
## [993] 175.7750 166.8094 169.0750 175.3000 165.3568 165.2000 148.4648 162.5000

```

4. Use `rnorm` to generate some normally distributed noise with mean 0.0 and sd of 10.0 for each of the

values.

```
noise <- rnorm(1000, mean=0, sd=10)
hist(noise)
```



5. Add the noise-free weights to the noise to get your simulated outcome data.

```
weights <- no_noise_weights + noise
```

6. Put these together in a dataframe with columns for age, weight (the observed outcome with noise), trueFx (the noise-free weight value), and noise.

```
df <- data.frame(age=age, weight=weights, trueFx=no_noise_weights, noise=noise)
df
```

##	age	weight	trueFx	noise
## 1	43	161.6581	150.4222	11.23585423
## 2	78	160.6807	168.2792	-7.59845657
## 3	40	155.8896	144.4000	11.48959103
## 4	73	165.1934	173.6182	-8.42476259
## 5	62	178.6829	174.7688	3.91413340
## 6	53	175.5880	166.6742	8.91377242
## 7	57	157.7952	171.1478	-13.35258713
## 8	72	178.2820	174.3008	3.98123478

## 9	60	172.4841	173.6000	-1.11586803
## 10	60	180.3574	173.6000	6.75743917
## 11	49	153.0794	160.9654	-7.88597935
## 12	46	155.0957	155.9656	-0.86986334
## 13	48	173.1860	159.3632	13.82284008
## 14	54	169.5993	167.9144	1.68490164
## 15	60	181.8319	173.6000	8.23190948
## 16	76	168.6007	170.8096	-2.20894598
## 17	80	154.9061	165.2000	-10.29391655
## 18	64	175.4331	175.5424	-0.10925691
## 19	76	158.5597	170.8096	-12.24991155
## 20	76	144.8485	170.8096	-25.96111388
## 21	73	185.3094	173.6182	11.69122592
## 22	64	164.6733	175.5424	-10.86908817
## 23	54	149.6536	167.9144	-18.26083013
## 24	72	184.2536	174.3008	9.95281807
## 25	59	172.7548	172.8734	-0.11861781
## 26	74	166.8141	172.8104	-5.99628395
## 27	45	152.3955	154.1750	-1.77947987
## 28	49	156.7056	160.9654	-4.25981342
## 29	77	179.5784	169.6118	9.96658776
## 30	59	180.1500	172.8734	7.27660709
## 31	67	158.6535	175.9198	-17.26630596
## 32	59	176.4074	172.8734	3.53398496
## 33	62	182.0369	174.7688	7.26813666
## 34	45	160.8576	154.1750	6.68260976
## 35	79	142.5662	166.8094	-24.24317309
## 36	64	173.1888	175.5424	-2.35357425
## 37	45	173.9713	154.1750	19.79633321
## 38	78	176.2471	168.2792	7.96794539
## 39	45	137.0822	154.1750	-17.09276181
## 40	63	158.5695	175.2062	-16.63668712
## 41	71	179.7717	174.8606	4.91109552
## 42	53	164.9336	166.6742	-1.74055486
## 43	41	156.0695	146.4566	9.61290564
## 44	57	174.0861	171.1478	2.93826662
## 45	61	175.0426	174.2326	0.80999364
## 46	53	168.5108	166.6742	1.83661843
## 47	77	171.2744	169.6118	1.66255035
## 48	40	131.7040	144.4000	-12.69599066
## 49	79	190.3043	166.8094	23.49493321
## 50	45	140.0549	154.1750	-14.12005407
## 51	62	174.5992	174.7688	-0.16961493
## 52	45	148.7318	154.1750	-5.44319353
## 53	79	184.8105	166.8094	18.00112333
## 54	78	178.3936	168.2792	10.11440176
## 55	50	156.8628	162.5000	-5.63716556
## 56	56	172.2078	170.1536	2.05420795
## 57	75	183.5296	171.8750	11.65461950
## 58	52	187.7200	165.3568	22.36322840
## 59	79	169.8321	166.8094	3.02265076
## 60	64	165.1173	175.5424	-10.42506602
## 61	64	165.7070	175.5424	-9.83542313
## 62	62	194.8260	174.7688	20.05718580

## 63	59	152.1677	172.8734	-20.70571484
## 64	78	198.8366	168.2792	30.55742369
## 65	68	173.2137	175.8272	-2.61350594
## 66	52	160.8129	165.3568	-4.54393259
## 67	61	175.8082	174.2326	1.57560555
## 68	68	185.1611	175.8272	9.33388728
## 69	67	178.9481	175.9198	3.02828276
## 70	72	154.7393	174.3008	-19.56150222
## 71	60	177.1354	173.6000	3.53536709
## 72	70	179.8042	175.3000	4.50424514
## 73	77	176.2073	169.6118	6.59550871
## 74	56	159.8394	170.1536	-10.31420728
## 75	48	135.6530	159.3632	-23.71022881
## 76	78	165.0334	168.2792	-3.24576308
## 77	62	165.3258	174.7688	-9.44298751
## 78	58	164.3963	172.0552	-7.65889998
## 79	65	166.2372	175.7750	-9.53779267
## 80	69	171.6414	175.6214	-3.98004450
## 81	71	171.7484	174.8606	-3.11217063
## 82	78	176.2401	168.2792	7.96092713
## 83	68	185.6915	175.8272	9.86428344
## 84	73	165.6729	173.6182	-7.94531662
## 85	49	157.8772	160.9654	-3.08817972
## 86	40	148.0144	144.4000	3.61444766
## 87	65	189.7629	175.7750	13.98791105
## 88	54	167.3537	167.9144	-0.56070420
## 89	68	158.8385	175.8272	-16.98873492
## 90	63	177.5247	175.2062	2.31852545
## 91	51	162.7737	163.9646	-1.19090671
## 92	78	186.0041	168.2792	17.72492853
## 93	63	178.6404	175.2062	3.43422165
## 94	67	169.6893	175.9198	-6.23049782
## 95	61	169.8374	174.2326	-4.39522294
## 96	79	161.7564	166.8094	-5.05296790
## 97	72	176.1612	174.3008	1.86035137
## 98	58	173.8194	172.0552	1.76417798
## 99	65	184.9335	175.7750	9.15848207
## 100	74	176.0122	172.8104	3.20176726
## 101	40	140.7331	144.4000	-3.66687297
## 102	68	166.4211	175.8272	-9.40611295
## 103	53	173.0212	166.6742	6.34702931
## 104	61	173.6077	174.2326	-0.62488482
## 105	45	156.0034	154.1750	1.82837868
## 106	67	186.9562	175.9198	11.03641018
## 107	80	182.7204	165.2000	17.52035619
## 108	76	161.2714	170.8096	-9.53816460
## 109	42	164.9056	148.4648	16.44080457
## 110	61	165.5653	174.2326	-8.66733529
## 111	74	175.4739	172.8104	2.66352192
## 112	46	158.1893	155.9656	2.22370495
## 113	74	170.0413	172.8104	-2.76908510
## 114	80	179.1425	165.2000	13.94253041
## 115	66	169.3125	175.9016	-6.58912000
## 116	46	162.5709	155.9656	6.60531281

## 117	59	172.7408	172.8734	-0.13255700
## 118	63	165.8914	175.2062	-9.31480299
## 119	55	181.2219	169.0750	12.14689143
## 120	58	151.1718	172.0552	-20.88340366
## 121	75	166.6135	171.8750	-5.26152469
## 122	41	131.0426	146.4566	-15.41402567
## 123	40	146.3432	144.4000	1.94321070
## 124	78	170.9234	168.2792	2.64422549
## 125	80	154.0126	165.2000	-11.18735169
## 126	52	171.8663	165.3568	6.50952956
## 127	65	165.4460	175.7750	-10.32900239
## 128	73	180.2102	173.6182	6.59201499
## 129	41	148.8349	146.4566	2.37829400
## 130	58	179.2080	172.0552	7.15275947
## 131	56	160.7688	170.1536	-9.38483039
## 132	73	174.5717	173.6182	0.95354010
## 133	50	157.8718	162.5000	-4.62819420
## 134	70	160.6112	175.3000	-14.68882156
## 135	74	174.3373	172.8104	1.52686506
## 136	74	190.5480	172.8104	17.73762611
## 137	58	165.5745	172.0552	-6.48070934
## 138	50	160.5018	162.5000	-1.99817476
## 139	55	175.9674	169.0750	6.89243733
## 140	79	167.1709	166.8094	0.36145510
## 141	48	178.7986	159.3632	19.43536312
## 142	67	183.2919	175.9198	7.37213734
## 143	63	198.4195	175.2062	23.21333933
## 144	49	164.4545	160.9654	3.48909346
## 145	54	156.5752	167.9144	-11.33916661
## 146	76	175.0230	170.8096	4.21335268
## 147	71	165.6150	174.8606	-9.24556257
## 148	76	160.7390	170.8096	-10.07062366
## 149	78	166.3845	168.2792	-1.89474330
## 150	70	184.6392	175.3000	9.33916700
## 151	76	174.2487	170.8096	3.43910000
## 152	68	183.9674	175.8272	8.14020276
## 153	51	173.1180	163.9646	9.15341002
## 154	53	164.9557	166.6742	-1.71852130
## 155	77	145.5895	169.6118	-24.02231114
## 156	55	177.0341	169.0750	7.95906852
## 157	54	189.6056	167.9144	21.69115869
## 158	41	147.0404	146.4566	0.58383499
## 159	40	130.8509	144.4000	-13.54914450
## 160	42	144.7893	148.4648	-3.67550766
## 161	48	150.0180	159.3632	-9.34517579
## 162	77	169.1954	169.6118	-0.41639220
## 163	56	176.9147	170.1536	6.76112006
## 164	59	181.5378	172.8734	8.66436147
## 165	44	154.6782	152.3264	2.35175025
## 166	80	155.8603	165.2000	-9.33970133
## 167	66	184.0341	175.9016	8.13252167
## 168	70	188.7832	175.3000	13.48318555
## 169	47	180.2146	157.6958	22.51882776
## 170	75	166.9385	171.8750	-4.93652434

## 171	80	169.9409	165.2000	4.74092599
## 172	68	187.7641	175.8272	11.93691666
## 173	60	172.4360	173.6000	-1.16395472
## 174	40	149.6486	144.4000	5.24858556
## 175	59	175.0176	172.8734	2.14421481
## 176	63	173.8617	175.2062	-1.34449535
## 177	61	175.9177	174.2326	1.68509103
## 178	77	179.2591	169.6118	9.64732770
## 179	55	173.1628	169.0750	4.08778914
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## 182	41	138.5060	146.4566	-7.95063185
## 183	47	157.4962	157.6958	-0.19955117
## 184	53	141.5299	166.6742	-25.14425122
## 185	75	193.9845	171.8750	22.10952032
## 186	65	160.8874	175.7750	-14.88762230
## 187	79	155.2019	166.8094	-11.60751876
## 188	76	185.3870	170.8096	14.57738225
## 189	47	135.7970	157.6958	-21.89875949
## 190	46	163.3562	155.9656	7.39062681
## 191	75	168.4349	171.8750	-3.44008769
## 192	75	176.4338	171.8750	4.55876742
## 193	48	168.1443	159.3632	8.78110263
## 194	66	166.3170	175.9016	-9.58463923
## 195	80	158.1416	165.2000	-7.05844846
## 196	54	137.9449	167.9144	-29.96949303
## 197	77	160.0013	169.6118	-9.61052324
## 198	45	157.9769	154.1750	3.80188254
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## 200	74	193.0810	172.8104	20.27056004
## 201	74	173.4567	172.8104	0.64627029
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## 203	80	165.9478	165.2000	0.74778333
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## 205	64	183.0315	175.5424	7.48910821
## 206	70	179.9423	175.3000	4.64234581
## 207	76	172.1038	170.8096	1.29420458
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## 216	53	167.8848	166.6742	1.21058163
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## 218	51	155.1579	163.9646	-8.80670730
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## 222	73	184.9679	173.6182	11.34965089
## 223	65	186.8943	175.7750	11.11931845
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## 225	43	152.5295	150.4222	2.10731585
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## 228	63	183.3146	175.2062	8.10839980
## 229	76	151.6861	170.8096	-19.12345796
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## 231	53	176.6557	166.6742	9.98154445
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## 233	57	168.9840	171.1478	-2.16375791
## 234	72	158.0814	174.3008	-16.21937293
## 235	71	160.3510	174.8606	-14.50963965
## 236	47	161.2049	157.6958	3.50909731
## 237	78	166.5337	168.2792	-1.74546929
## 238	46	150.0513	155.9656	-5.91428470
## 239	66	162.5613	175.9016	-13.34027261
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## 241	59	193.2344	172.8734	20.36103609
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## 243	76	178.5497	170.8096	7.74005212
## 244	68	183.6773	175.8272	7.85006401
## 245	50	170.1325	162.5000	7.63246080
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## 247	42	135.9412	148.4648	-12.52355924
## 248	77	159.5168	169.6118	-10.09503753
## 249	80	172.7139	165.2000	7.51391195
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## 251	67	181.1952	175.9198	5.27540097
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## 271	74	174.3290	172.8104	1.51856040
## 272	49	161.3854	160.9654	0.41998754
## 273	45	156.4092	154.1750	2.23422312
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## 275	72	198.3130	174.3008	24.01222102
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## 278	74	184.9393	172.8104	12.12889371

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## 306	74	173.0458	172.8104	0.23541985
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## 311	48	161.0096	159.3632	1.64639155
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## 315	61	174.1411	174.2326	-0.09148952
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## 318	58	189.0291	172.0552	16.97393895
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## 333 76 177.8691 170.8096 7.05945571
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## 488	40	150.7345	144.4000	6.33448919
## 489	41	141.3648	146.4566	-5.09180774
## 490	48	150.7931	159.3632	-8.57008619
## 491	44	168.4881	152.3264	16.16167577
## 492	66	185.8403	175.9016	9.93866407
## 493	68	182.7957	175.8272	6.96845859
## 494	41	163.4563	146.4566	16.99970673

## 495	76	161.0322	170.8096	-9.77741945
## 496	70	195.7882	175.3000	20.48817582
## 497	53	178.9387	166.6742	12.26449324
## 498	64	178.6126	175.5424	3.07023012
## 499	60	179.8433	173.6000	6.24332984
## 500	62	175.3822	174.7688	0.61341442
## 501	45	153.0667	154.1750	-1.10825791
## 502	60	157.8377	173.6000	-15.76233560
## 503	44	159.7523	152.3264	7.42589846
## 504	64	196.9656	175.5424	21.42323398
## 505	56	191.0513	170.1536	20.89772957
## 506	72	175.9987	174.3008	1.69794327
## 507	79	165.7306	166.8094	-1.07877789
## 508	58	173.8751	172.0552	1.81994495
## 509	56	181.6129	170.1536	11.45928178
## 510	59	187.6464	172.8734	14.77298823
## 511	62	178.8482	174.7688	4.07944153
## 512	59	184.0162	172.8734	11.14278735
## 513	70	175.0292	175.3000	-0.27075844
## 514	44	157.3036	152.3264	4.97722203
## 515	66	187.7580	175.9016	11.85640014
## 516	72	210.6965	174.3008	36.39573627
## 517	40	143.8600	144.4000	-0.54002596
## 518	68	169.1457	175.8272	-6.68147317
## 519	73	178.0763	173.6182	4.45807957
## 520	75	167.8167	171.8750	-4.05825246
## 521	59	179.2262	172.8734	6.35283145
## 522	60	177.0125	173.6000	3.41248399
## 523	77	182.7735	169.6118	13.16167163
## 524	63	165.6084	175.2062	-9.59776484
## 525	73	161.5624	173.6182	-12.05575211
## 526	59	188.5491	172.8734	15.67573058
## 527	42	150.7177	148.4648	2.25285800
## 528	59	163.6493	172.8734	-9.22410657
## 529	73	162.8805	173.6182	-10.73772410
## 530	54	162.3908	167.9144	-5.52358286
## 531	69	181.5260	175.6214	5.90461401
## 532	52	160.0840	165.3568	-5.27275411
## 533	55	182.4935	169.0750	13.41846164
## 534	75	174.3134	171.8750	2.43844628
## 535	69	177.5802	175.6214	1.95880789
## 536	68	175.6720	175.8272	-0.15519729
## 537	67	172.9440	175.9198	-2.97577328
## 538	52	163.6800	165.3568	-1.67679147
## 539	46	167.5304	155.9656	11.56478580
## 540	57	157.7602	171.1478	-13.38764009
## 541	40	155.2677	144.4000	10.86768775
## 542	43	146.9154	150.4222	-3.50684197
## 543	44	159.6736	152.3264	7.34723245
## 544	75	171.2909	171.8750	-0.58414484
## 545	73	160.1601	173.6182	-13.45812904
## 546	65	179.2441	175.7750	3.46905269
## 547	72	167.9168	174.3008	-6.38404647
## 548	58	183.2991	172.0552	11.24392355

## 549	56	161.8763	170.1536	-8.27733031
## 550	52	147.4790	165.3568	-17.87780138
## 551	78	159.7391	168.2792	-8.54010003
## 552	75	166.1548	171.8750	-5.72022722
## 553	46	147.7063	155.9656	-8.25930679
## 554	61	171.8568	174.2326	-2.37584094
## 555	48	153.4099	159.3632	-5.95326496
## 556	71	170.7532	174.8606	-4.10742195
## 557	79	170.0893	166.8094	3.27991438
## 558	72	162.6643	174.3008	-11.63646612
## 559	67	183.5216	175.9198	7.60177665
## 560	51	163.9390	163.9646	-0.02555836
## 561	69	175.2391	175.6214	-0.38227771
## 562	74	152.4480	172.8104	-20.36237420
## 563	65	172.7627	175.7750	-3.01229079
## 564	42	142.9083	148.4648	-5.55646104
## 565	54	176.3874	167.9144	8.47295416
## 566	78	182.1874	168.2792	13.90820511
## 567	62	187.0813	174.7688	12.31246215
## 568	64	164.4090	175.5424	-11.13337462
## 569	40	136.4395	144.4000	-7.96053893
## 570	67	175.0246	175.9198	-0.89519877
## 571	48	148.7666	159.3632	-10.59656888
## 572	53	150.6311	166.6742	-16.04312194
## 573	70	183.2135	175.3000	7.91350666
## 574	55	169.7566	169.0750	0.68156528
## 575	60	179.7440	173.6000	6.14396000
## 576	51	151.9339	163.9646	-12.03067753
## 577	69	172.2169	175.6214	-3.40454835
## 578	61	162.5201	174.2326	-11.71248634
## 579	40	136.1059	144.4000	-8.29414768
## 580	51	166.2567	163.9646	2.29212042
## 581	67	167.7699	175.9198	-8.14992918
## 582	51	154.0301	163.9646	-9.93445515
## 583	64	162.4807	175.5424	-13.06168459
## 584	64	161.2002	175.5424	-14.34221772
## 585	47	149.0673	157.6958	-8.62847933
## 586	70	192.3380	175.3000	17.03799204
## 587	44	145.7701	152.3264	-6.55632596
## 588	51	152.8329	163.9646	-11.13168626
## 589	69	161.5663	175.6214	-14.05505446
## 590	48	157.8568	159.3632	-1.50643687
## 591	41	142.5165	146.4566	-3.94006912
## 592	48	161.8839	159.3632	2.52069320
## 593	80	162.3729	165.2000	-2.82706438
## 594	80	173.8767	165.2000	8.67667613
## 595	61	181.4335	174.2326	7.20091121
## 596	66	186.4623	175.9016	10.56069601
## 597	77	172.0468	169.6118	2.43502060
## 598	62	185.9124	174.7688	11.14362662
## 599	73	172.8527	173.6182	-0.76552714
## 600	42	157.7941	148.4648	9.32925054
## 601	40	142.8202	144.4000	-1.57981739
## 602	41	139.6415	146.4566	-6.81509515

## 603	58	159.8542	172.0552	-12.20101091
## 604	68	168.7381	175.8272	-7.08912992
## 605	44	144.8396	152.3264	-7.48679598
## 606	73	179.3790	173.6182	5.76077526
## 607	80	164.6790	165.2000	-0.52099464
## 608	51	157.6612	163.9646	-6.30337174
## 609	80	156.2166	165.2000	-8.98336066
## 610	57	186.2747	171.1478	15.12685876
## 611	73	171.2507	173.6182	-2.36749293
## 612	52	152.8688	165.3568	-12.48803422
## 613	78	163.9791	168.2792	-4.30009336
## 614	43	151.3552	150.4222	0.93299436
## 615	45	162.5054	154.1750	8.33041089
## 616	62	173.9195	174.7688	-0.84932478
## 617	64	176.6609	175.5424	1.11853039
## 618	55	158.6806	169.0750	-10.39435943
## 619	61	182.1968	174.2326	7.96422814
## 620	65	176.7740	175.7750	0.99903376
## 621	79	174.1790	166.8094	7.36959753
## 622	53	182.1430	166.6742	15.46881334
## 623	45	155.9642	154.1750	1.78920972
## 624	47	154.8703	157.6958	-2.82546592
## 625	60	165.9270	173.6000	-7.67298779
## 626	63	169.4422	175.2062	-5.76404240
## 627	42	139.3162	148.4648	-9.14855840
## 628	79	170.5085	166.8094	3.69910961
## 629	76	156.1328	170.8096	-14.67684363
## 630	53	149.2206	166.6742	-17.45361978
## 631	66	169.2278	175.9016	-6.67381804
## 632	52	176.1996	165.3568	10.84279006
## 633	58	173.2835	172.0552	1.22831641
## 634	42	143.5223	148.4648	-4.94249395
## 635	68	182.5231	175.8272	6.69588184
## 636	44	148.8116	152.3264	-3.51478853
## 637	64	174.3926	175.5424	-1.14980401
## 638	70	176.0299	175.3000	0.72986942
## 639	53	177.5619	166.6742	10.88774613
## 640	75	184.8007	171.8750	12.92568738
## 641	59	185.6985	172.8734	12.82511294
## 642	70	185.0906	175.3000	9.79056118
## 643	52	168.6515	165.3568	3.29469783
## 644	42	167.2612	148.4648	18.79635718
## 645	79	187.2384	166.8094	20.42899031
## 646	63	188.4920	175.2062	13.28576373
## 647	68	173.6305	175.8272	-2.19668644
## 648	49	150.5649	160.9654	-10.40047432
## 649	52	167.2863	165.3568	1.92949783
## 650	45	148.6226	154.1750	-5.55236252
## 651	49	163.7153	160.9654	2.74990890
## 652	78	162.7741	168.2792	-5.50513405
## 653	58	181.2678	172.0552	9.21259893
## 654	57	193.0424	171.1478	21.89455992
## 655	60	183.2399	173.6000	9.63994790
## 656	62	182.1870	174.7688	7.41818476

## 657	65	176.1486	175.7750	0.37356565
## 658	54	189.7227	167.9144	21.80833686
## 659	68	175.0313	175.8272	-0.79585204
## 660	68	189.5902	175.8272	13.76295029
## 661	44	168.0796	152.3264	15.75316677
## 662	61	175.8364	174.2326	1.60376978
## 663	40	111.8678	144.4000	-32.53220073
## 664	61	170.9333	174.2326	-3.29930487
## 665	52	169.9277	165.3568	4.57089826
## 666	61	161.1916	174.2326	-13.04103757
## 667	45	141.2633	154.1750	-12.91173439
## 668	80	174.2638	165.2000	9.06379732
## 669	72	146.3412	174.3008	-27.95961495
## 670	63	177.5418	175.2062	2.33560571
## 671	61	171.5422	174.2326	-2.69035939
## 672	72	167.7153	174.3008	-6.58545055
## 673	49	161.5989	160.9654	0.63345793
## 674	58	172.6000	172.0552	0.54476839
## 675	47	160.1659	157.6958	2.47009323
## 676	51	165.2050	163.9646	1.24035548
## 677	50	157.1474	162.5000	-5.35256700
## 678	55	171.6598	169.0750	2.58482591
## 679	60	187.4771	173.6000	13.87708868
## 680	45	160.8467	154.1750	6.67170446
## 681	63	190.1767	175.2062	14.97049452
## 682	65	173.0262	175.7750	-2.74880403
## 683	47	163.5266	157.6958	5.83075843
## 684	60	178.6336	173.6000	5.03358526
## 685	46	148.5331	155.9656	-7.43247682
## 686	74	164.6416	172.8104	-8.16877585
## 687	72	193.0036	174.3008	18.70283681
## 688	69	167.3489	175.6214	-8.27253044
## 689	44	161.8335	152.3264	9.50712694
## 690	44	149.6647	152.3264	-2.66172351
## 691	43	139.4314	150.4222	-10.99082182
## 692	50	147.1578	162.5000	-15.34217543
## 693	80	153.1369	165.2000	-12.06309860
## 694	41	126.9563	146.4566	-19.50025273
## 695	49	152.1250	160.9654	-8.84040030
## 696	73	183.3523	173.6182	9.73405985
## 697	41	140.6469	146.4566	-5.80971316
## 698	51	181.3323	163.9646	17.36767382
## 699	45	152.4482	154.1750	-1.72675318
## 700	48	149.9833	159.3632	-9.37992532
## 701	78	165.4333	168.2792	-2.84593660
## 702	58	166.1650	172.0552	-5.89018102
## 703	44	147.8871	152.3264	-4.43931426
## 704	56	170.7536	170.1536	0.59996573
## 705	48	160.1855	159.3632	0.82232949
## 706	64	183.1264	175.5424	7.58397524
## 707	52	170.7534	165.3568	5.39662991
## 708	51	171.7311	163.9646	7.76647647
## 709	74	174.1321	172.8104	1.32171665
## 710	47	149.6271	157.6958	-8.06865300

## 711	41	150.9501	146.4566	4.49350086
## 712	48	163.4896	159.3632	4.12641457
## 713	70	171.2639	175.3000	-4.03614049
## 714	46	152.0847	155.9656	-3.88088277
## 715	44	163.2783	152.3264	10.95187748
## 716	46	169.3704	155.9656	13.40480043
## 717	78	169.4233	168.2792	1.14405547
## 718	70	171.3774	175.3000	-3.92264620
## 719	41	162.9802	146.4566	16.52357843
## 720	59	160.4364	172.8734	-12.43697609
## 721	80	156.0807	165.2000	-9.11925871
## 722	47	166.1962	157.6958	8.50043472
## 723	64	166.2893	175.5424	-9.25312995
## 724	74	181.7462	172.8104	8.93581214
## 725	60	164.1899	173.6000	-9.41009738
## 726	71	180.2501	174.8606	5.38952094
## 727	55	167.2553	169.0750	-1.81974398
## 728	46	164.8833	155.9656	8.91767595
## 729	64	188.8345	175.5424	13.29208205
## 730	58	171.0205	172.0552	-1.03466125
## 731	74	178.9610	172.8104	6.15064611
## 732	64	157.5447	175.5424	-17.99772395
## 733	52	162.7297	165.3568	-2.62705142
## 734	49	148.8640	160.9654	-12.10141877
## 735	73	175.6630	173.6182	2.04477253
## 736	55	168.9351	169.0750	-0.13994105
## 737	50	160.1480	162.5000	-2.35200840
## 738	63	173.3230	175.2062	-1.88318654
## 739	42	157.9776	148.4648	9.51283069
## 740	46	154.4255	155.9656	-1.54014786
## 741	69	194.1638	175.6214	18.54244505
## 742	61	155.1909	174.2326	-19.04167354
## 743	71	178.4536	174.8606	3.59299702
## 744	62	195.9141	174.7688	21.14534946
## 745	63	163.8487	175.2062	-11.35748987
## 746	51	156.0020	163.9646	-7.96255986
## 747	67	171.9441	175.9198	-3.97569450
## 748	47	158.6130	157.6958	0.91724042
## 749	62	172.3819	174.7688	-2.38694074
## 750	52	160.7372	165.3568	-4.61962364
## 751	57	190.4112	171.1478	19.26340607
## 752	41	147.6771	146.4566	1.22054815
## 753	80	176.1205	165.2000	10.92050577
## 754	51	134.2420	163.9646	-29.72257475
## 755	49	172.2503	160.9654	11.28489051
## 756	62	187.8888	174.7688	13.12000129
## 757	45	149.3489	154.1750	-4.82607973
## 758	47	155.4472	157.6958	-2.24858997
## 759	62	191.4465	174.7688	16.67765311
## 760	52	165.7690	165.3568	0.41218532
## 761	69	186.0031	175.6214	10.38174846
## 762	73	179.4946	173.6182	5.87642933
## 763	47	156.1128	157.6958	-1.58299577
## 764	51	161.0437	163.9646	-2.92085415

## 765	61	160.0336	174.2326	-14.19898963
## 766	62	153.3856	174.7688	-21.38318025
## 767	42	148.2398	148.4648	-0.22500105
## 768	43	153.1199	150.4222	2.69770954
## 769	60	168.5703	173.6000	-5.02969399
## 770	51	170.2727	163.9646	6.30807390
## 771	63	179.9519	175.2062	4.74565208
## 772	52	161.9502	165.3568	-3.40659062
## 773	46	156.4616	155.9656	0.49601560
## 774	66	188.8542	175.9016	12.95263191
## 775	61	177.3788	174.2326	3.14624205
## 776	74	180.8261	172.8104	8.01572504
## 777	71	179.7212	174.8606	4.86058896
## 778	44	169.5820	152.3264	17.25561057
## 779	77	170.6361	169.6118	1.02432861
## 780	66	166.0032	175.9016	-9.89837075
## 781	49	156.3610	160.9654	-4.60441209
## 782	68	178.2038	175.8272	2.37661492
## 783	52	162.6628	165.3568	-2.69397264
## 784	51	162.2691	163.9646	-1.69554070
## 785	66	182.5503	175.9016	6.64868973
## 786	78	160.5237	168.2792	-7.75550915
## 787	40	125.2074	144.4000	-19.19261131
## 788	48	179.5565	159.3632	20.19332540
## 789	74	177.1625	172.8104	4.35210515
## 790	50	173.0017	162.5000	10.50168832
## 791	79	163.6883	166.8094	-3.12114841
## 792	75	172.8112	171.8750	0.93617617
## 793	76	149.2777	170.8096	-21.53187751
## 794	49	164.5453	160.9654	3.57993071
## 795	60	178.2786	173.6000	4.67864811
## 796	75	162.8081	171.8750	-9.06688835
## 797	62	169.4753	174.7688	-5.29349916
## 798	67	189.3556	175.9198	13.43576717
## 799	71	179.5549	174.8606	4.69434057
## 800	64	173.0113	175.5424	-2.53105088
## 801	63	178.8972	175.2062	3.69103715
## 802	51	150.4975	163.9646	-13.46707190
## 803	44	164.0458	152.3264	11.71935426
## 804	70	156.2126	175.3000	-19.08736345
## 805	56	160.1097	170.1536	-10.04390811
## 806	45	160.9419	154.1750	6.76687514
## 807	68	187.3504	175.8272	11.52321744
## 808	58	154.7276	172.0552	-17.32759918
## 809	65	181.7881	175.7750	6.01308857
## 810	66	179.3181	175.9016	3.41650314
## 811	40	144.0472	144.4000	-0.35281009
## 812	40	138.1383	144.4000	-6.26165020
## 813	48	150.8035	159.3632	-8.55971210
## 814	45	155.6928	154.1750	1.51777842
## 815	75	183.9387	171.8750	12.06372694
## 816	64	160.6566	175.5424	-14.88577883
## 817	43	139.9185	150.4222	-10.50374123
## 818	48	175.7419	159.3632	16.37874117

## 819	48	147.2899	159.3632	-12.07334181
## 820	78	142.0176	168.2792	-26.26155085
## 821	75	172.0496	171.8750	0.17463266
## 822	58	175.4971	172.0552	3.44194027
## 823	43	150.5494	150.4222	0.12719837
## 824	74	164.0759	172.8104	-8.73450133
## 825	68	179.2552	175.8272	3.42800284
## 826	55	167.3011	169.0750	-1.77387754
## 827	42	157.6791	148.4648	9.21433255
## 828	80	168.2094	165.2000	3.00944402
## 829	75	178.8089	171.8750	6.93386753
## 830	59	176.1281	172.8734	3.25471906
## 831	53	170.7547	166.6742	4.08051023
## 832	53	174.2726	166.6742	7.59842256
## 833	72	151.4293	174.3008	-22.87153520
## 834	40	149.5784	144.4000	5.17838262
## 835	74	159.3380	172.8104	-13.47236258
## 836	58	175.6868	172.0552	3.63159859
## 837	63	188.3537	175.2062	13.14752565
## 838	50	158.0169	162.5000	-4.48305911
## 839	62	166.6872	174.7688	-8.08164468
## 840	41	145.5939	146.4566	-0.86268499
## 841	78	184.1334	168.2792	15.85424273
## 842	59	173.8840	172.8734	1.01057448
## 843	53	168.1618	166.6742	1.48762212
## 844	49	155.5011	160.9654	-5.46434668
## 845	60	168.3232	173.6000	-5.27675587
## 846	72	172.9021	174.3008	-1.39871559
## 847	71	158.9665	174.8606	-15.89411414
## 848	67	188.2608	175.9198	12.34104166
## 849	67	172.5653	175.9198	-3.35454848
## 850	46	135.9556	155.9656	-20.01002507
## 851	43	150.2476	150.4222	-0.17458403
## 852	64	173.1327	175.5424	-2.40966896
## 853	69	157.7015	175.6214	-17.91989399
## 854	69	196.1183	175.6214	20.49691511
## 855	76	159.6374	170.8096	-11.17217612
## 856	71	161.3251	174.8606	-13.53549545
## 857	79	171.3224	166.8094	4.51302311
## 858	49	171.2977	160.9654	10.33227425
## 859	62	172.8099	174.7688	-1.95885695
## 860	48	161.6363	159.3632	2.27310387
## 861	72	163.2788	174.3008	-11.02199750
## 862	50	172.0528	162.5000	9.55277369
## 863	59	176.0017	172.8734	3.12830446
## 864	59	173.8835	172.8734	1.01005713
## 865	73	181.0994	173.6182	7.48115414
## 866	48	169.3528	159.3632	9.98960895
## 867	52	158.0316	165.3568	-7.32515309
## 868	44	157.1354	152.3264	4.80895240
## 869	42	138.5703	148.4648	-9.89450308
## 870	65	198.0706	175.7750	22.29559048
## 871	56	174.7210	170.1536	4.56736600
## 872	40	144.0418	144.4000	-0.35815444

## 873	47	152.7914	157.6958	-4.90442706
## 874	58	169.8495	172.0552	-2.20566611
## 875	57	160.1357	171.1478	-11.01209361
## 876	41	147.0913	146.4566	0.63470471
## 877	61	180.0679	174.2326	5.83525933
## 878	75	166.7414	171.8750	-5.13358846
## 879	43	142.2967	150.4222	-8.12552122
## 880	53	150.3810	166.6742	-16.29319906
## 881	50	168.1891	162.5000	5.68905707
## 882	55	172.4128	169.0750	3.33783307
## 883	64	173.4292	175.5424	-2.11322559
## 884	75	166.3640	171.8750	-5.51097930
## 885	44	154.9100	152.3264	2.58361129
## 886	66	162.1495	175.9016	-13.75210446
## 887	70	160.5725	175.3000	-14.72754149
## 888	66	161.4495	175.9016	-14.45209673
## 889	41	142.8437	146.4566	-3.61288425
## 890	80	173.1071	165.2000	7.90709965
## 891	71	182.0072	174.8606	7.14657846
## 892	62	169.1173	174.7688	-5.65153517
## 893	59	187.0535	172.8734	14.18014303
## 894	45	142.7174	154.1750	-11.45756781
## 895	44	147.3982	152.3264	-4.92817823
## 896	58	164.7247	172.0552	-7.33052274
## 897	57	172.7401	171.1478	1.59232080
## 898	73	156.1063	173.6182	-17.51192959
## 899	60	185.4483	173.6000	11.84830867
## 900	78	180.3495	168.2792	12.07031601
## 901	59	182.6499	172.8734	9.77649327
## 902	65	174.9551	175.7750	-0.81991744
## 903	71	186.4232	174.8606	11.56263423
## 904	78	173.1472	168.2792	4.86796337
## 905	79	176.3979	166.8094	9.58848663
## 906	49	162.7433	160.9654	1.77792371
## 907	50	165.4225	162.5000	2.92250881
## 908	60	152.4666	173.6000	-21.13340685
## 909	52	159.9763	165.3568	-5.38047911
## 910	59	183.0137	172.8734	10.14025585
## 911	77	170.6245	169.6118	1.01269641
## 912	46	143.7785	155.9656	-12.18707372
## 913	76	161.2258	170.8096	-9.58376793
## 914	68	170.2692	175.8272	-5.55797485
## 915	56	191.3724	170.1536	21.21875912
## 916	47	155.8999	157.6958	-1.79589988
## 917	77	163.1644	169.6118	-6.44735408
## 918	71	153.9348	174.8606	-20.92583772
## 919	63	156.1875	175.2062	-19.01870838
## 920	45	166.3975	154.1750	12.22250276
## 921	62	166.2566	174.7688	-8.51220441
## 922	49	177.1774	160.9654	16.21202883
## 923	50	159.2090	162.5000	-3.29102802
## 924	49	137.7013	160.9654	-23.26409527
## 925	53	188.6042	166.6742	21.92998000
## 926	55	158.2502	169.0750	-10.82479976

## 927	66	170.8380	175.9016	-5.06360967
## 928	80	166.1592	165.2000	0.95918957
## 929	40	143.1983	144.4000	-1.20165258
## 930	43	135.2355	150.4222	-15.18667630
## 931	78	153.1733	168.2792	-15.10585063
## 932	62	188.7248	174.7688	13.95604928
## 933	71	167.7764	174.8606	-7.08421944
## 934	55	177.3544	169.0750	8.27938353
## 935	79	183.8870	166.8094	17.07755837
## 936	59	165.0817	172.8734	-7.79166557
## 937	43	143.3532	150.4222	-7.06899069
## 938	48	139.4342	159.3632	-19.92902511
## 939	55	188.0738	169.0750	18.99876533
## 940	70	167.7379	175.3000	-7.56206936
## 941	49	157.1858	160.9654	-3.77955780
## 942	72	160.6613	174.3008	-13.63954801
## 943	79	174.2290	166.8094	7.41958159
## 944	56	186.2634	170.1536	16.10975996
## 945	52	167.6307	165.3568	2.27387447
## 946	64	171.5372	175.5424	-4.00515674
## 947	57	154.4520	171.1478	-16.69580400
## 948	64	190.4494	175.5424	14.90701097
## 949	49	167.8803	160.9654	6.91487433
## 950	68	175.4174	175.8272	-0.40977477
## 951	48	171.4066	159.3632	12.04344853
## 952	43	163.4073	150.4222	12.98514964
## 953	65	171.1528	175.7750	-4.62217021
## 954	77	157.3541	169.6118	-12.25773748
## 955	57	180.7805	171.1478	9.63266754
## 956	74	179.7425	172.8104	6.93211228
## 957	40	139.3861	144.4000	-5.01393166
## 958	60	205.1397	173.6000	31.53971417
## 959	53	141.1831	166.6742	-25.49106895
## 960	69	175.5400	175.6214	-0.08138085
## 961	40	155.7878	144.4000	11.38780641
## 962	62	189.5923	174.7688	14.82346468
## 963	80	174.9585	165.2000	9.75845009
## 964	58	173.5387	172.0552	1.48350293
## 965	66	183.7907	175.9016	7.88908757
## 966	46	161.5414	155.9656	5.57581220
## 967	53	166.4003	166.6742	-0.27394393
## 968	71	166.0899	174.8606	-8.77074959
## 969	53	178.8366	166.6742	12.16243471
## 970	67	172.4073	175.9198	-3.51249812
## 971	59	169.9295	172.8734	-2.94393117
## 972	40	146.9314	144.4000	2.53137809
## 973	46	156.0806	155.9656	0.11497986
## 974	67	156.1620	175.9198	-19.75783962
## 975	63	170.9429	175.2062	-4.26326724
## 976	65	181.8980	175.7750	6.12302560
## 977	69	187.9295	175.6214	12.30814109
## 978	76	158.1015	170.8096	-12.70807808
## 979	63	168.7006	175.2062	-6.50555664
## 980	67	151.4881	175.9198	-24.43166237

```
## 981 79 176.7749 166.8094 9.96548595
## 982 77 169.6629 169.6118 0.05113528
## 983 62 182.6790 174.7688 7.91024764
## 984 68 170.1953 175.8272 -5.63191537
## 985 79 168.9477 166.8094 2.13826203
## 986 54 177.6852 167.9144 9.77082664
## 987 49 158.6238 160.9654 -2.34161103
## 988 74 181.2970 172.8104 8.48660554
## 989 64 182.0821 175.5424 6.53970891
## 990 48 143.4575 159.3632 -15.90570026
## 991 53 169.7684 166.6742 3.09423133
## 992 58 147.1954 172.0552 -24.85982190
## 993 65 172.9906 175.7750 -2.78439107
## 994 79 161.2851 166.8094 -5.52433759
## 995 55 177.8354 169.0750 8.76042073
## 996 70 178.2348 175.3000 2.93483694
## 997 52 159.3846 165.3568 -5.97222047
## 998 80 163.6280 165.2000 -1.57203603
## 999 42 150.3067 148.4648 1.84185060
## 1000 50 152.3697 162.5000 -10.13032014
```

7. Generate a plot of weight against age.

```
plot(weights, age, pch=19, cex=0.4)
```

Applying smoothing kernels:

1. Fit a nearest neighbors curve with `ksmooth` using a bandwidth of 10 and the `box` kernel.

```
box_curve <- ksmooth(df$age, df$weight, kernel = "box", bandwidth = 10)
plot(box_curve)
```

2. Fit another curve this time using the `normal` kernel.

```
normal_curve <- ksmooth(df$age, df$weight, kernel = "normal", bandwidth = 10)
```

3. Plot the data with the two fitted curves and compare them. Hint: look at the object you have generated with `ksmooth` (i.e. type `name_of_the_object` or `print(name_of_the_object)`). Also, try `names(name_of_the_object)`. Use the command lines to plot the curves.

```
plot(age, weights, pch=19, cex=0.4)
lines(box_curve$x, box_curve$y, lwd=3, col="red")
lines(normal_curve$x, normal_curve$y, lwd=3, col="blue")
legend("bottomright", cex=0.8, lwd=3, lty=c(1,1,2,3), c("box bw=10", "normal bw=10"), col=c("red", "blue"))
```

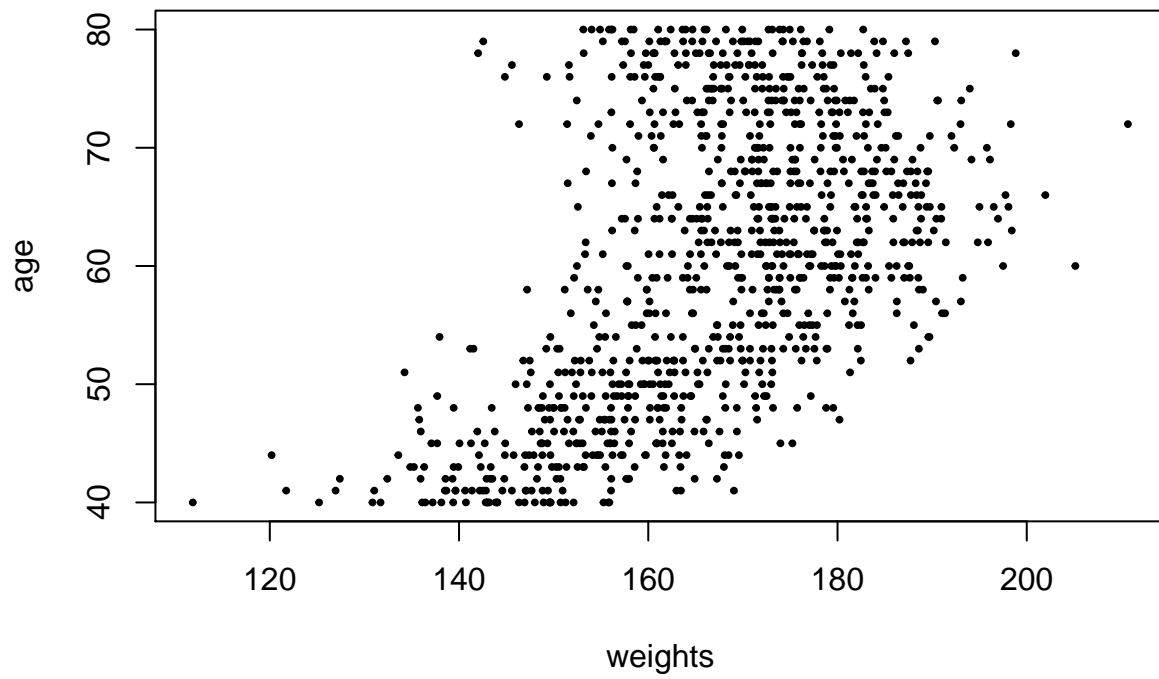



Figure 1: Figure: Age vs Weights

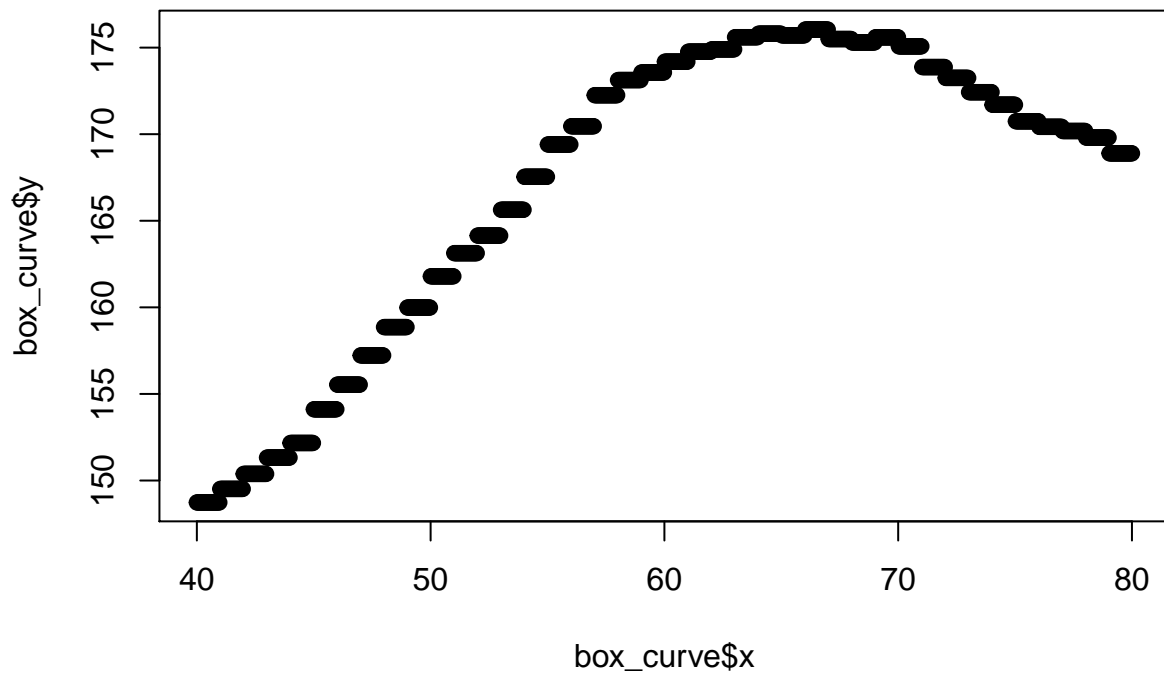
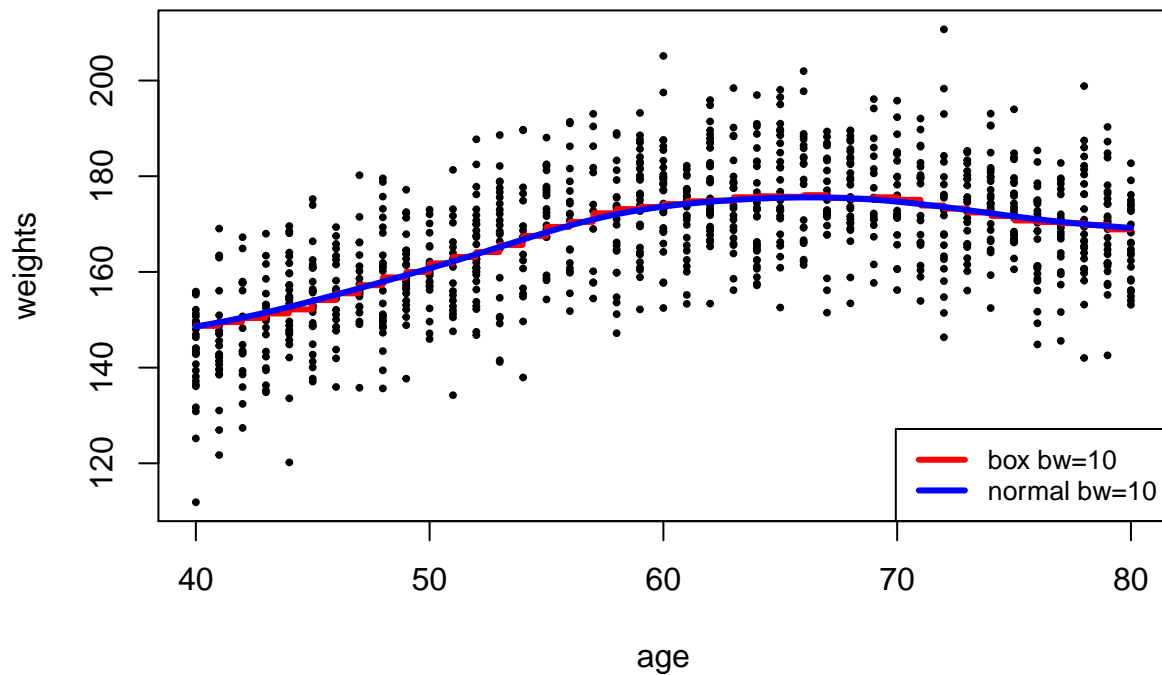


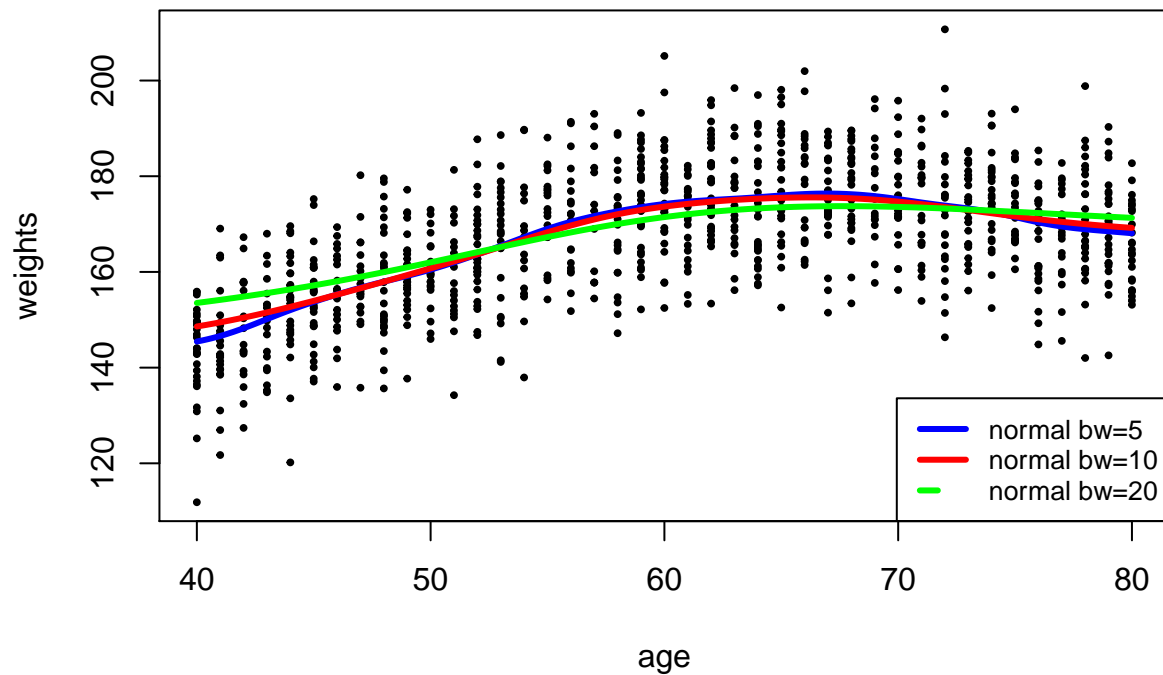
Figure 2: ksmooth curve of age against weight



4. Fit another 2 curves with the “normal” kernel using bandwidths of size 5, 10, and 20. How do they compare?

```
normal_curve5 <- ksmooth(df$age, df$weight, kernel = "normal", bandwidth = 5)
normal_curve10 <- ksmooth(df$age, df$weight, kernel = "normal", bandwidth = 10)
normal_curve20 <- ksmooth(df$age, df$weight, kernel = "normal", bandwidth = 20)

plot(age, weights, pch=19, cex=0.4)
lines(normal_curve5$x, normal_curve5$y, lwd=3, col="blue")
lines(normal_curve10$x, normal_curve10$y, lwd=3, col="red")
lines(normal_curve20$x, normal_curve20$y, lwd=3, col="green")
legend("bottomright", cex=0.8, lwd=3, lty=c(1,1,2,3), c("normal bw=5", "normal bw=10", "normal bw=20"), col=c("blue", "red", "green", "black"))
```



Fitting linear models:

1. Fit a linear regression to the data using the `lm` command.

```
head(df)
```

```
##   age  weight  trueFx   noise
## 1  43 161.6581 150.4222 11.235854
## 2  78 160.6807 168.2792 -7.598457
## 3  40 155.8896 144.4000 11.489591
## 4  73 165.1934 173.6182 -8.424763
## 5  62 178.6829 174.7688  3.914133
## 6  53 175.5880 166.6742  8.913772
```

```
linear_model <- lm(weight ~ age, data=df)
```

2. Run `summary(your_linear_model_name)` to get an idea of the fit

```
summary(linear_model)
```

```
##
## Call:
## lm(formula = weight ~ age, data = df)
```

```
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -42.605  -8.218  -0.198   8.245  38.326
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) 129.79005     1.96776   65.96  <2e-16 ***
## age          0.61706     0.03204   19.26  <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 12.06 on 998 degrees of freedom
## Multiple R-squared:  0.271, Adjusted R-squared:  0.2702
## F-statistic: 370.9 on 1 and 998 DF,  p-value: < 2.2e-16
```

- Now fit quadratic and cubic models: you will need the I function to set quadratic and cubic terms in the regression, e.g. $I(x^2)$

```
#quadratic model
quadratic_model <- lm(weight ~ age + I(age^2), data=df)
summary(quadratic_model)
```

```
##
## Call:
## lm(formula = weight ~ age + I(age^2), data = df)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -31.209  -6.762   0.176   7.299  36.560
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) -36.54398     9.044877  -4.04 5.75e-05 ***
## age          6.385785     0.309374   20.64 < 2e-16 ***
## I(age^2)     -0.048051     0.002567  -18.72 < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 10.38 on 997 degrees of freedom
## Multiple R-squared:  0.4606, Adjusted R-squared:  0.4595
## F-statistic: 425.7 on 2 and 997 DF,  p-value: < 2.2e-16
```

```
#cubic model
cubic_model <- lm(weight ~ age + I(age^2) + I(age^3), data=df)
summary(cubic_model)
```

```
##
## Call:
## lm(formula = weight ~ age + I(age^2) + I(age^3), data = df)
##
## Residuals:
```

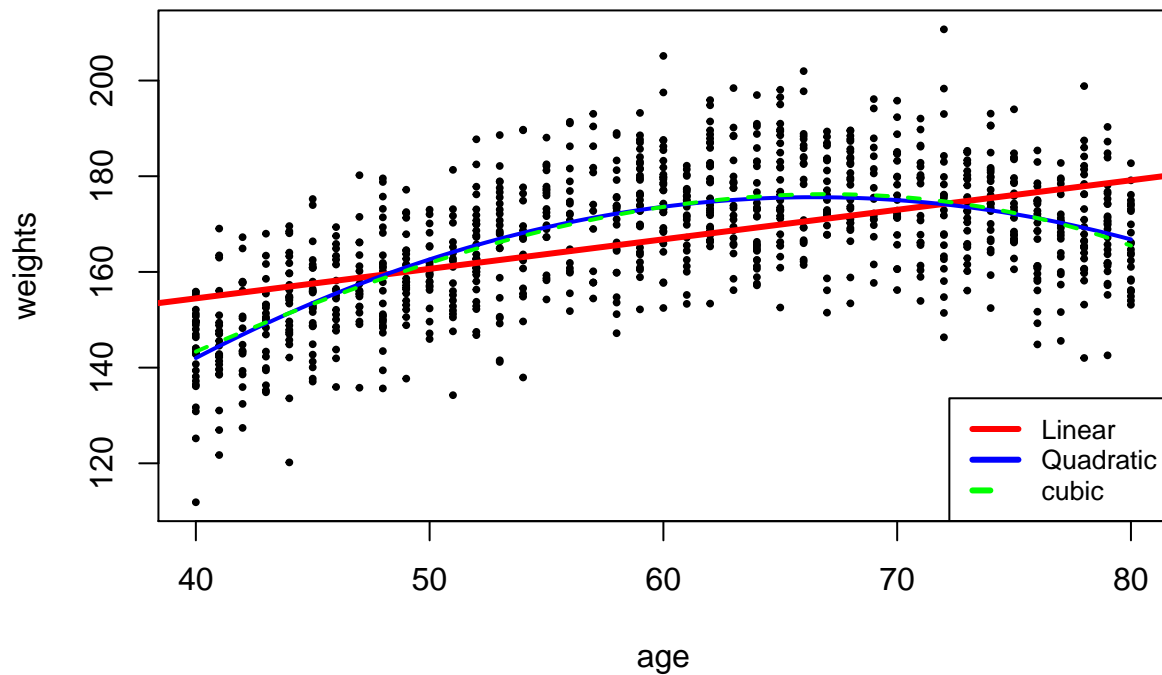
```
##      Min      1Q  Median      3Q      Max
## -31.472  -6.905  -0.044   7.288  35.946
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) 56.1267168 51.0925279   1.099   0.2722
## age         1.5209614   2.6579063   0.572   0.5673
## I(age^2)     0.0348917   0.0450815   0.774   0.4391
## I(age^3)    -0.0004602   0.0002497  -1.843   0.0657 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 10.36 on 996 degrees of freedom
## Multiple R-squared:  0.4624, Adjusted R-squared:  0.4608
## F-statistic: 285.6 on 3 and 996 DF,  p-value: < 2.2e-16
```

4. Add the fitted models to the plots. For the linear model, use the `abline` command. For the polynomial fits, you can use the `curve` command (you will need the option `add = TRUE`).

```
?predict
?predict.lm
?curve

quad_predict <- function(age) {predict(quadratic_model, newdata = data.frame(age=age))}
cubic_predict <- function(age) {predict(cubic_model, newdata = data.frame(age=age))}

plot(age, weights, pch=19, cex=0.4)
abline(linear_model, col="red", lwd=3)
curve(quad_predict, col="blue", lwd=2, add=T)
curve(cubic_predict, col="green", lwd=2, lty=2, add=T)
legend("bottomright", cex=0.8, lwd=3, lty=c(1,1,2), c("Linear", "Quadratic", "cubic"), col = c("red", "blue", "green"))
```



5. Which curve do you prefer? How would you perform a hypothesis test for this?

```
anova(linear_model, quadratic_model, cubic_model)
```

```
## Analysis of Variance Table
##
## Model 1: weight ~ age
## Model 2: weight ~ age + I(age^2)
## Model 3: weight ~ age + I(age^2) + I(age^3)
##   Res.Df    RSS Df Sum of Sq    F Pr(>F)
## 1     998 145050
## 2     997 107323  1    37727 351.315 < 2e-16 ***
## 3     996 106958  1     365   3.396 0.06565 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Practice installing an R package

6. R packages are easy to install using the `install.packages` command. Try installing the `e1071` package. We'll use this package later in the course for fitting support vector machines.

```
# install.packages("e1071")
```