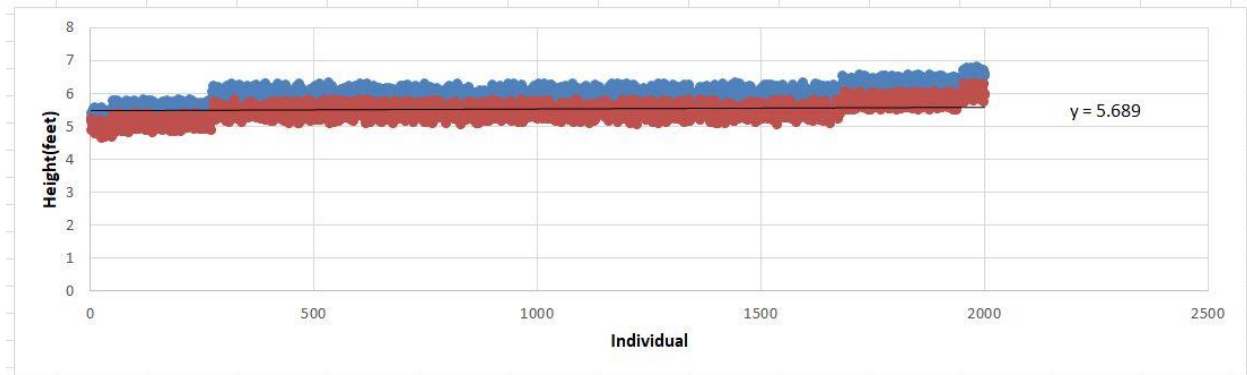


Code and data is located at the last few pages for this document.

## Scenario where only the first feature (height) is considered

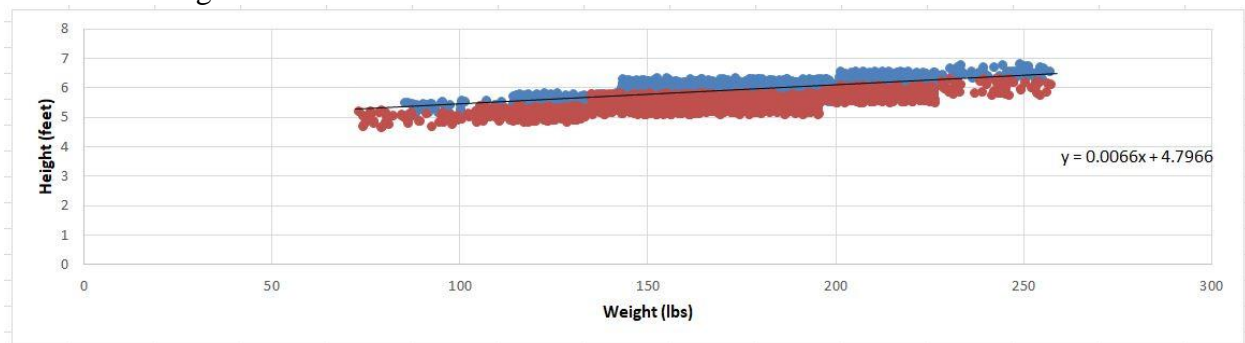
1. In the graph, red is female data, blue is male data. Both types of data are not generalized.



2. The separation/decision line function is  $y=5.689$ . This is the median between the average height of males and females.
3. The equation of the decision function is  $y=5.689$ . If the person's height is  $>5.689$  then this person is considered male. If the person's height is  $\leq 5.689$  then this person is considered female.
  - a. In class, all the biological neuron models have a set threshold, so in this case, our threshold would be 5.689 and so when our linear combination (in this case just the height considered) then the neuron would fire, else it will not fire.
4.
  - a. Error is  $(407+452)/4000=21.475\%$
  - b. Accuracy is  $(1548+1593)/4000=78.525\%$
  - c. True Positive Rate - (when person is determined to be male they are actually male)  $1548/2000 = 77.4\%$
  - d. True Negative Rate - (when person is determined to be female they are actually female)  $1593/2000 = 79.65\%$
  - e. False Positive Rate - (when person is determined to be male is actually female)  $407/2000 = 20.35\%$
  - f. False Negative Rate - (when person is determined to be female is actually male)  $452/2000 = 22.6\%$

## Scenario where both features (height and weight) are considered

1. In the graph, red is female data, blue is male data. Both types of data are not generalized.



2. The separation/decision line function is  $\text{height} = 0.0066 * \text{weight} + 4.7966$ . We used the medium of max height between male height and female height while both male and female are in maximum weight, divided by the minimum height between male height and female height while both male and female are in minimum.

3. The equation of the decision function is  $\text{height} = 0.0066 * \text{weight} + 4.7966$ . If the person's height is  $> 0.0066 * \text{weight} + 4.7966$ , then this person is a male. If the person's height is  $\leq 0.0066 * \text{weight} + 4.7966$ , then this person is a female.

- b. In class, all the biological neuron models have a set threshold, but in this case, we cannot put a set numeric weight as a deterministic factor and use that as the threshold because a human's height and weight have certain correlation. A man with height over 6 feet is very unlikely to weigh less than 100 lbs, so we consider both height and weight as variable inputs.

4.

- g.  $\text{Error} = (21 + 1042) / 4000 = 26.575\%$
- h.  $\text{Accuracy} = (1042 + 1979) / 4000 = 75.525\%$
- i. True Positive Rate - (when person is determined to be male they are actually male)  
 $1042 / 2000 = 52.1\%$
- j. True Negative Rate - (when person is determined to be female they are actually female)  
 $1979 / 2000 = 98.95\%$
- k. False Positive Rate - (when person is determined to be male is actually female)  $21 / 2000 = 1.05\%$
- l. False Negative Rate - (when person is determined to be female is actually male)  
 $958 / 2000 = 47.9\%$

Part 2.

Truth table without memory element for reference.

A	B	OUT
0	0	0
0	1	0
1	0	1

1. Memory is not consider random 1's or 0's, its pre-assigned

A (WRITE 1) +1	B (WRITE 0) -2	C(MEMORY)+1	T=0.5	OUT
0	0	0	$0 < T$	0
0	0	1	$1 > T$	1
0	1	0	$-2 < T$	0
0	1	1	$-1 < T$	0
1	0	0	$1 > T$	1
1	0	1	$2 > T$	1

2. The range of possible values for threshold in cases with previously stored zero or one are between 0 (non-inclusive) and 2 (inclusive).  $0 < T \leq 2$ .
3. The case we cannot consider is writing 1 and 0 at the same time, so a truth table with values 1 for both A and B as shown below.

A (WRITE 1)	B (WRITE B)	C(MEMORY)
1	1	0
1	1	1

The equation would be  $(A+C)\bar{B}$

Code for generating random height and weight data:

Note that each time the code is run, data generated will always vary slightly, since data is randomly generated.

```
/*Team FUL
* Memeber, Aplomb Huang, Aaron Kim, Paige Fuller
*CMSC 409 PROJECT01 INSTRUCTOR DR. Manic
* This program will randomly generate heights and weights for both
Male and Female
*and writes that to the txt file.
*/
```

```
import java.io.*;
import java.math.*;
import java.util.Random;
```

```
public class Project01
{
```

```
    public static void main(String[] args) throws IOException
    {
```

```
        File f = new File("data.txt");
        double height;
        double weight;
```

```
        PrintWriter writer = new PrintWriter(new FileWriter(f));
```

```
        for(int i = 0; i <2000; i++)
        {
```

```
            //2 std. dev. left
            if (i<50)
            {
```

```
                Random random = new Random();
                height = random.nextInt(2) + 60;
                height /= 12;
                height += (random.nextDouble())/2;
                weight = random.nextInt(28) + 85;
                weight += (random.nextDouble())/2; //Water Weight
                //System.out.println (height + ", " + weight + ",
```

```
0");
```

```
                writer.printf(height + ", " + weight + ", 0 \n");
```

```
            }
```

```
            // 1 std. dev. left
            else if (i <270)
            {
```

```
                Random random = new Random();
                height = random.nextInt(2) + 63;
                height /= 12;
```

```

        height += (random.nextDouble())/2;
        weight = random.nextInt(28) + 114;
        weight += (random.nextDouble())/2; //Water Weight
        //System.out.println (height + ", " + weight + ",
0");

        writer.printf(height + ", " + weight + ", 0 \n");
    }

    //std. dev. center
else if (i<1680){
    Random random = new Random();
    height = random.nextInt(5) + 66;

    height /= 12;
    height += (random.nextDouble())/2;

    weight = random.nextInt(57) + 143;
    weight += (random.nextDouble())/2; //Water Weight
    //System.out.println (height + ", " + weight + ",
0");

    writer.printf(height + ", " + weight + ", 0 \n");
}
// 1 std. dev. right
else if (i<1950)
{
    Random random = new Random();
    height = random.nextInt(2) + 72;
    height /= 12;
    height += (random.nextDouble())/2;
    weight = random.nextInt(28) + 201;
    weight += (random.nextDouble())/2; //Water Weight
    //System.out.println (height + ", " + weight + ",
0");

    writer.printf(height + ", " + weight + ", 0 \n");
}

//2 std. dev. right
else
{
    Random random = new Random();
    height = random.nextInt(2) + 75;
    height /= 12;
    height += (random.nextDouble())/2;
    weight = random.nextInt(28) + 230;
    weight += (random.nextDouble())/2; //Water Weight
    //System.out.println (height + ", " + weight + ",
0");

    writer.printf(height + ", " + weight + ", 0 \n");
}

```

```

    }

}

writer.printf(" \n");

//Female Statistics
for(int i = 0; i <2000; i++)
{
    //2 std. dev. left
    if(i<50)
    {
        Random random = new Random();
        height = random.nextInt(2) + 56;
        height /= 12;
        height += (random.nextDouble())/2;
        weight = random.nextInt(30) + 73;
        weight += (random.nextDouble())/2; //Water Weight
        //System.out.println (height + ", " + weight + ",
1");

        writer.printf(height + ", " + weight + ", 1 \n");
    }

    // 1 std. dev. left
    else if (i <270)
    {
        Random random = new Random();
        height = random.nextInt(2) + 58;
        height /= 12;
        height += (random.nextDouble())/2;
        weight = random.nextInt(30) + 104;
        weight += (random.nextDouble())/2; //Water Weight
        //System.out.println (height + ", " + weight + ",
1");

        writer.printf(height + ", " + weight + ", 1 \n");
    }

    //std. dev. center
    else if (i<1680)
    {
        Random random = new Random();
        height = random.nextInt(4) + 61;
        height /= 12;
        height += (random.nextDouble())/2;
        weight = random.nextInt(61) + 135;
        weight += (random.nextDouble())/2; //Water Weight
        //System.out.println (height + ", " + weight + ",
1");

        writer.printf(height + ", " + weight + ", 1 \n");
    }
}

```

```

    }
    // 1 std. dev. right
    else if (i<1950)
    {
        Random random = new Random();
        height = random.nextInt(2) + 66;
        height /= 12;
        height += (random.nextDouble())/2;
        weight = random.nextInt(30) + 197;
        weight += (random.nextDouble())/2; //Water Weight
        //System.out.println (height + ", " + weight + ",
1");

        writer.printf(height + ", " + weight + ", 1 \n");
    }

    //2 std. dev. right
    else
    {
        Random random = new Random();
        height = random.nextInt(2) + 69;
        height /= 12;
        height += (random.nextDouble())/2;
        weight = random.nextInt(30) + 228;
        weight += (random.nextDouble())/2; //Water Weight
        // System.out.println (height + ", " + weight + ",
1");

        writer.printf(height + ", " + weight + ", 1 \n");
    }
}

writer.close();
}
}

```

Data used to plot the graph:

male height(ft)	male weight(lbs)	
5.41761837	100.3054344	0
5.173218241	91.4898486	0
5.270727183	110.4590222	0
5.453144418	87.39718704	0
5.43607277	110.2504075	0
5.509462927	95.07777836	0
5.546387641	111.0420253	0
5.472151203	92.45141285	0
5.393886762	89.15794319	0
5.581518963	107.0866371	0
5.091965299	86.10936972	0
5.493096462	86.2569203	0
5.1824654	94.27194384	0
5.439160012	90.39771958	0
5.451671591	92.2976141	0
5.066191462	102.3882067	0
5.516485858	95.18470725	0
5.421773283	109.3493815	0
5.311260121	93.06736927	0
5.55368256	95.26817076	0
5.131057715	97.22797394	0
5.169805379	100.2073296	0
5.423097016	97.38676898	0
5.578404215	100.4233208	0
5.418760131	91.11145438	0
5.26627063	96.43498682	0
5.305931299	96.06316102	0
5.057543519	99.38628924	0
5.491203271	85.31006361	0
5.160281811	107.1159731	0
5.179326534	112.4015512	0
5.089205225	107.2648375	0
5.131715502	88.26479542	0
5.160174256	106.2874408	0
5.29490053	100.1513393	0
5.435049043	111.1520074	0
5.418991729	88.49954339	0
5.21186303	107.4151512	0
5.340086155	93.3952631	0
5.126521692	107.3707203	0
5.420901321	87.20067146	0
5.53560808	101.3653283	0
5.136714836	106.0302499	0
5.112739963	87.22921494	0



5.282068632	91.47284246	0
5.226338998	104.2620182	0
5.461626448	90.24188089	0
5.272815531	90.02974445	0
5.450619918	106.2962222	0
5.241482766	105.0251901	0
5.795604269	138.3825697	0
5.725534648	125.0085477	0
5.688863478	118.0450516	0
5.797123544	124.0811304	0
5.566479436	141.3013691	0
5.381997889	121.1780483	0
5.519288551	124.381612	0
5.728167576	132.423242	0
5.466653185	123.3796652	0
5.796691019	116.0142046	0
5.667309147	133.4821335	0
5.464730459	116.0366286	0
5.580648263	127.2385385	0
5.371485499	133.1430113	0
5.536925268	137.2678754	0
5.705809666	118.4344629	0
5.626129896	124.0039889	0
5.535618215	129.2271766	0
5.254810078	132.2342833	0
5.700962625	140.2234486	0
5.489736242	122.090297	0
5.468295338	133.0041628	0
5.527961104	135.4083946	0
5.73185691	134.3863516	0
5.502124582	132.4507464	0
5.645915663	127.4234823	0
5.437241973	131.3528801	0
5.34389542	122.1058996	0
5.334580082	129.3751721	0
5.778769505	117.3517559	0
5.697628481	119.4361452	0
5.715645197	126.0286799	0
5.626748132	132.2485817	0
5.623831433	128.1228919	0
5.474676401	119.4628434	0
5.583806647	129.1127618	0
5.277796533	114.3439512	0
5.698657701	115.0349401	0
5.748817759	128.0987336	0

5.549918731	124.2056286	0
5.376182542	114.2184744	0
5.50378439	137.0041658	0
5.655166007	119.1158521	0
5.432844307	118.2800569	0
5.570161814	124.0697622	0
5.499735347	129.2723177	0
5.345425313	129.0992121	0
5.69013476	127.1396146	0
5.808141664	130.1047843	0
5.657122195	115.4331089	0
5.361417681	131.4840195	0
5.255422852	116.2517797	0
5.721205226	116.4400345	0
5.344870283	133.0911044	0
5.741354571	137.0901754	0
5.639639945	125.009455	0
5.550892862	139.0096987	0
5.700317682	124.0857973	0
5.67485986	140.391584	0
5.272992243	120.1330814	0
5.292554612	137.3444092	0
5.706047212	123.4693738	0
5.373515805	119.2161235	0
5.5018459	125.0059467	0
5.728178438	132.0846895	0
5.721904757	118.2225866	0
5.270917171	132.3739633	0
5.813436636	120.4386018	0
5.589499125	121.4318026	0
5.582959021	141.3370999	0
5.74825547	138.4736018	0
5.368387146	123.4960471	0
5.779000378	124.1754088	0
5.584803709	135.4079187	0
5.703074539	119.0185138	0
5.57584954	128.1452179	0
5.513193397	139.1197806	0
5.716082672	136.2615438	0
5.499568453	134.1140932	0
5.645095046	140.3015871	0
5.478468477	132.0564328	0
5.802787913	118.29518	0
5.635872782	127.0365136	0
5.34953396	135.2376029	0

5.778983634	133.0750809	0
5.297700172	139.08675	0
5.30914304	137.2653294	0
5.735078685	119.3906591	0
5.587677122	128.1832906	0
5.446040732	116.0523764	0
5.535354	117.103741	0
5.752763085	123.0149022	0
5.661146151	139.0000104	0
5.457382631	130.025529	0
5.406995977	119.4407269	0
5.379516613	138.1965579	0
5.702464068	140.1511669	0
5.679551765	129.2360016	0
5.397020901	120.4303642	0
5.406273698	122.0543174	0
5.703481833	136.3199699	0
5.461092721	133.4751401	0
5.63119318	136.4609363	0
5.442360382	131.2830821	0
5.565449696	122.3051903	0
5.661307231	130.1281243	0
5.363286608	117.4309994	0
5.560510389	122.1071126	0
5.507528182	134.2210127	0
5.751778185	115.4014131	0
5.601164555	132.0930711	0
5.649096229	136.3896378	0
5.559874207	121.3315415	0
5.51279138	129.4334724	0
5.503970705	115.1541744	0
5.446820819	123.2464468	0
5.364630152	124.1346186	0
5.760628224	115.135264	0
5.453929472	134.2179398	0
5.476436808	139.4271269	0
5.314102918	140.2790242	0
5.797255263	138.0486437	0
5.710424546	120.4314236	0
5.293962264	131.3711428	0
5.51299035	132.0221755	0
5.433527937	126.3123801	0
5.360429253	116.161019	0
5.359291939	129.0025905	0
5.389617319	123.1613981	0

5.49162717	130.4704599	0
5.386047407	118.3303988	0
5.493900267	116.4073829	0
5.745902917	138.0558345	0
5.681034515	114.4312955	0
5.395067622	118.2664458	0
5.560299536	125.3489518	0
5.512784445	129.4526347	0
5.4766696	114.0592286	0
5.277322027	135.3821031	0
5.71822411	121.015477	0
5.481550107	139.1551826	0
5.709105116	134.2047098	0
5.302982755	139.1752431	0
5.358863762	136.0244766	0
5.500815519	138.0199731	0
5.81801452	141.4655436	0
5.731665151	134.3704338	0
5.36331466	123.3303722	0
5.637705606	133.472919	0
5.617402055	140.1249784	0
5.735035588	114.1846226	0
5.54010332	117.202389	0
5.250077755	134.3496071	0
5.701150209	122.3090241	0
5.785709383	141.2719279	0
5.693294717	132.0095642	0
5.369787557	114.0915974	0
5.681546669	139.0693954	0
5.646668764	118.281334	0
5.702029776	137.129992	0
5.516894965	131.2373865	0
5.703980585	136.1229369	0
5.519759168	114.0858398	0
5.494088081	139.2717537	0
5.49064183	129.2811999	0
5.700723518	120.1687583	0
5.633528048	131.4291273	0
5.464564323	120.4367005	0
5.414391831	135.053585	0
5.466761975	121.4823179	0
5.829956865	122.3697463	0
5.49909277	140.1138995	0
5.467779953	126.137004	0
5.333610401	124.1980462	0

5.348660981	135.2072889	0
5.80546308	136.3082003	0
5.386649168	133.4526138	0
5.433304362	130.4813895	0
5.58127301	119.260324	0
5.522177617	133.2093048	0
5.665497502	125.3481245	0
5.73253728	136.3399655	0
5.436508254	120.3681513	0
5.310516765	129.329093	0
5.680443627	132.4073382	0
5.556846166	118.3939367	0
5.720719984	117.0714254	0
5.569051072	129.4543006	0
5.698603927	120.3748391	0
5.394397491	119.2748842	0
5.617146052	121.4886356	0
5.52341615	129.1355885	0
5.449376492	115.4476959	0
5.269142562	131.2520248	0
5.642423994	139.3891017	0
5.570086212	133.3449525	0
5.576526653	122.2270045	0
5.715735335	133.1688102	0
5.47280667	127.0543352	0
5.377879577	130.4055456	0
5.518300145	127.2154973	0
5.513005269	123.2520397	0
5.651951558	137.4127774	0
5.619076415	125.2312539	0
5.423793103	129.4123792	0
5.376487711	137.163414	0
5.725054631	125.2924281	0
5.36358241	120.3914942	0
5.543862861	140.3718993	0
5.742324831	128.3512753	0
5.319058205	137.2450919	0
5.525372484	115.0486024	0
5.517053025	123.4167293	0
5.76312671	135.2693907	0
5.649660704	135.3146161	0
5.712773412	115.3600124	0
5.828264084	126.001681	0
5.359904378	135.435761	0
5.669766475	121.4076441	0

5.465120819	139.4948128	0
5.741745789	198.0664177	0
6.057245324	149.0574014	0
5.603668397	198.3168358	0
5.950975606	143.0182801	0
5.758647232	183.2461448	0
6.249608087	197.3253313	0
5.925836061	197.123291	0
5.82981654	158.3468216	0
5.737095305	170.4005823	0
6.028187585	175.2755056	0
5.881325165	171.0526023	0
5.847280794	154.4565411	0
6.030898794	172.4735867	0
5.959179865	169.142811	0
6.033071144	151.0537514	0
6.210465304	179.3446328	0
6.1535276	190.2607366	0
5.787208482	143.3698129	0
5.612775584	177.3830574	0
6.16664962	171.2945383	0
5.693990057	155.3381629	0
6.012884322	183.0441717	0
5.913907948	164.1714282	0
5.825312105	196.0170741	0
6.042354187	190.1185789	0
5.967753875	179.0243464	0
5.943186591	159.24245	0
6.150728377	179.2973833	0
6.071189938	144.0064493	0
5.805370627	148.1276707	0
5.537500072	196.2298657	0
5.982313733	166.0928642	0
6.070055755	156.0403154	0
6.238917371	144.1322964	0
5.98680164	148.130205	0
5.817562599	188.355265	0
6.103746706	180.4007655	0
5.807457198	197.3046484	0
5.83708641	198.199048	0
6.163003181	195.2022244	0
6.033658989	152.0818854	0
5.878812194	153.4936635	0
5.61304483	175.4514216	0
6.316272252	179.2172171	0

5.677055599	171.4064687	0
5.995101407	191.3554354	0
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6.390014589	227.3093317	0
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6.520826812	221.4472818	0
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6.287344308	207.3280464	0
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6.424566953	236.274335	0
6.579507991	257.0351781	0
6.322428092	255.0531804	0
6.344259482	244.4307692	0
6.738162289	250.2436734	0
6.703549194	254.3852164	0
6.296210994	250.2560601	0
6.708405825	242.0463101	0
6.603187285	255.3963557	0
6.563440196	236.2387114	0
female	female	
height(ft)	weight(lbs)	
5.186440359	80.23500993	1
4.896492154	77.11311975	1
5.22660222	76.28687451	1
5.037051715	81.39439788	1
5.189259384	87.15781966	1
5.061716731	87.40726655	1
5.0882962	97.42957313	1
4.867441686	89.21559389	1
4.93390031	95.05418684	1
4.799236007	86.27758899	1
5.030279326	80.34512676	1
5.141040287	102.2338376	1
4.887296788	75.38669013	1
4.988495252	85.40980616	1
5.077807659	82.12069502	1
4.86264699	80.26529443	1
4.92523961	96.1517266	1
5.045365303	98.47134179	1
4.894349268	86.14901656	1
4.831804862	95.49061407	1
4.860261629	98.19254686	1
4.947936908	100.4512086	1

5.217355179	73.1795797	1
4.937836666	99.45267489	1
4.822813143	77.00713728	1
4.671667664	79.12013563	1
5.173239459	95.22178226	1
5.187420712	78.34945589	1
5.056559177	97.30469612	1
4.708024339	79.23577566	1
5.110574729	76.29343147	1
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5.086503804	95.09114337	1
4.760860235	98.02031964	1
5.136834396	76.13857305	1
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4.935083787	75.19970448	1
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5.047149403	113.1865306	1
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5.135715753	106.394821	1
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6.208803018	232.0065796	1
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