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HW9 Problem 6(a): Summary information for all athletes

athletes is a 202-by-5 matrix of observations

```
{labels, ht, wt, sex, lbm} = Transpose[athletes];

females = Take[athletes, 100];
{labels1, ht1, wt1, sex1, lbm1} = Transpose[females];

males = Drop[athletes, 100];
{labels0, ht0, wt0, sex0, lbm0} = Transpose[males];
```

N = 202	***Height (cm)***	***Weight (kg)***	***LBM (kg)***
Mean :	180.104	75.008	64.689
SD :	9.734	13.926	12.819

HW9 Problem 6(b): Height-LBM relationships

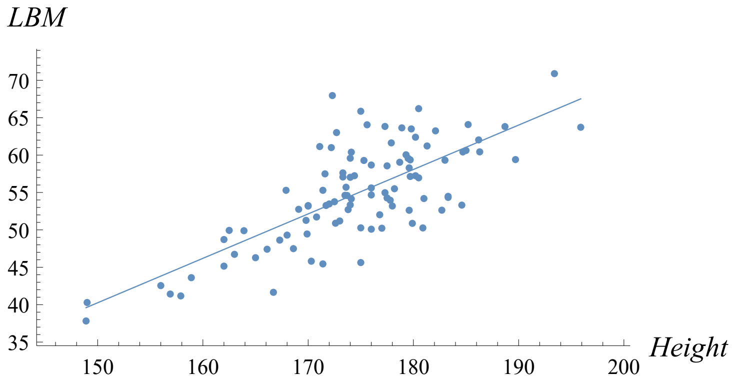
	Sample Size	***Mean Height***	***Mean LBM***	***Correlation (Ht, LBM)***
Males (0) :	102	185.506	74.324	0.714
Females (1) :	100	174.594	54.862	0.739

Male Results:

```
pairs = Transpose[{ht0, lbm0}];
Clear[x]; Remove[f];
f[x_] = Fit[pairs, {1, x}, x]
```

```
-88.7015 + 0.878815 x
```

```
SmoothPlot[{pairs, f},
 AxesLabel → {"Height", "LBM"}, AspectRatio → 1 / 2]
```

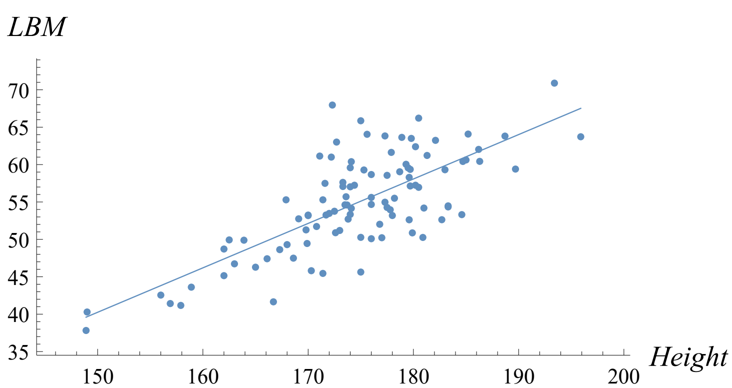


Female Results:

```
pairs = Transpose[{ht1, lbm1}];
Clear[x]; Remove[f];
f[x_] = Fit[pairs, {1, x}, x]
```

```
-48.8464 + 0.593999 x
```

```
SmoothPlot[{pairs, f},
 AxesLabel → {"Height", "LBM"}, AspectRatio → 1 / 2]
```



HW9 Problem 6(c): Weight-LBM relationships

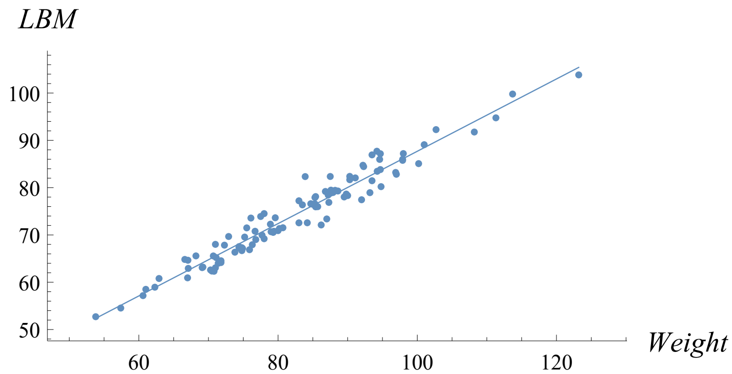
	Sample Size	*Mean Weight*	*Mean LBM*	*Correlation (Wt, LBM)*
Males (0) :	102	82.524	74.324	0.975
Females (1) :	100	67.343	54.862	0.956

Male Results:

```
pairs = Transpose[{wt0, lbm0}];
Clear[x]; Remove[f];
f[x_] = Fit[pairs, {1, x}, x]
```

```
11.2322 + 0.764529 x
```

```
SmoothPlot[{pairs, f},
 AxesLabel → {"Weight", "LBM"}, AspectRatio → 1 / 2]
```

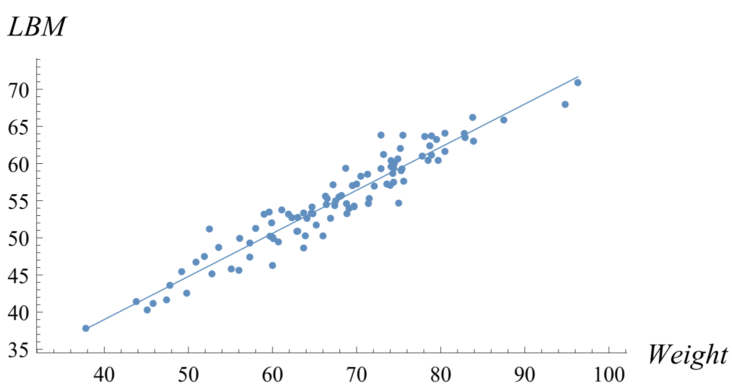


Female Results:

```
pairs = Transpose[{wt1, lbm1}];
Clear[x]; Remove[f];
f[x_] = Fit[pairs, {1, x}, x]
```

```
15.8003 + 0.58005 x
```

```
SmoothPlot[{pairs, f},
 AxesLabel → {"Weight", "LBM"}, AspectRatio → 1 / 2]
```



HW9 Problem 6(d): Ht-Wt-Sex-LBM relationship

```
Clear[x1, x2, x3]; Remove[f];
f[x1_, x2_, x3_] = Fit[athletes[[All, {2, 3, 4, 5}]],
  {1, x1, x2, x3, x1 * x3, x2 * x3}, {x1, x2, x3}]
```

```
-10.1506 + 0.142109 x1 + 0.704192 x2 +
 12.1539 x3 - 0.0425307 x1 x3 - 0.177433 x2 x3
```

```
lm = LinearModelFit[athletes[[All, {2, 3, 4, 5}]],
   {1, x1, x2, x3, x1 * x3, x2 * x3}, {x1, x2, x3}];
(* This line was giving me some trouble so I just squelched
 the output so that I could build the table *)
ANOVATable[lm]
```

	DF	SS	MS	F-Stat	P-Value
Model	5	32 284.1	6456.82	1701.57	0.
(x1)			21 555.9	5680.64	1.06911×10^{-146}
(x2)			7970.18	2100.39	1.07919×10^{-106}
(x3)			2495.4	657.615	1.5441×10^{-64}
(x1 x3)			152.598	40.2144	1.53707×10^{-9}
(x2 x3)			110.048	29.0011	2.05779×10^{-7}
Error	196	743.747	3.79463		
Total	201	33 027.9			

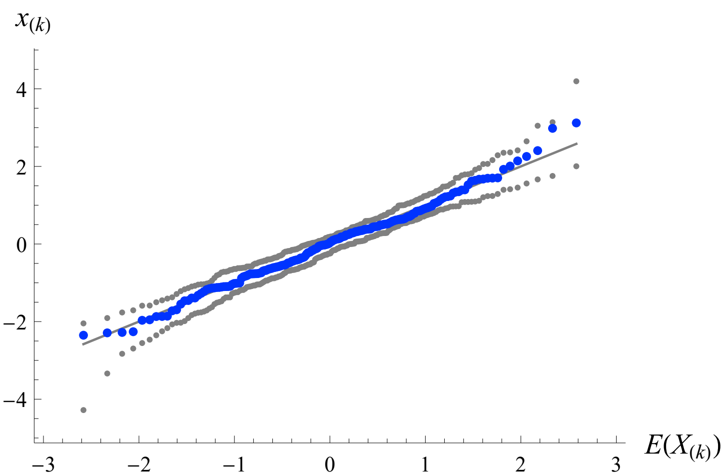
The estimated common standard deviation equals sqrt(3.794) = 1.947.
The coefficient of determination equals (33027.9-743.747)/33027.9 = 0.977.
From the results of the ANOVA table, we can see that height, weight, and gender all have statistically significant correlations with learn body mass. Individually, height, weight, and sex all have P-values approximately equal to zero. From our fitted line, we can observe that height, weight, and sex all had positive parameter estimates, which implies that being male, heavier, and taller all indicate a higher LBM and vice versa. Furthermore, the sex/height and sex/weight interaction terms also have P-values close to zero. From the results of our regression, we can see that because the interaction terms have negative signs, height and weight increases have a smaller impact on women's predicted LBM than men's. Finally, we observe a coefficient of determination of 0.977, which implies that this model does an excellent job of explaining variations in the data.

HW9 Problem 6(e): Predicted responses and confidence intervals

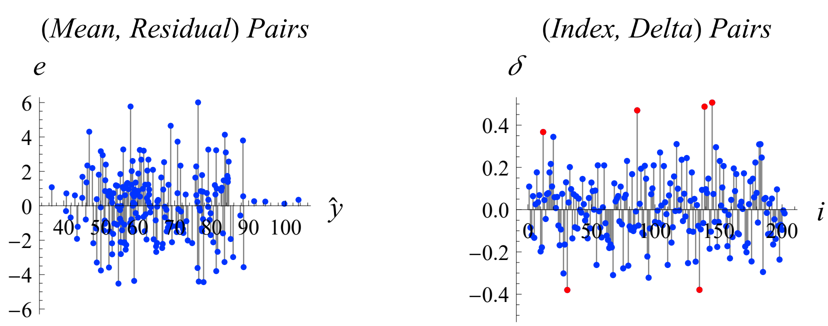
(ht, wt) = (180, 75)	***Predicted Response (kg)***	***95 % CI for Mean Response (kg)***
Males :	68.243	[67.773, 68.713]
Females :	59.434	[58.956, 59.912]

HW9 Problem 6(f): Discussion

```
standardized = lm["StandardizedResiduals"];
QuantileComparisonPlot[NormalDistribution[0, 1], standardized,
 SimulationBands → True]
```



```
DiagnosticSummary[lm]
```



```
Mean-Residual Pairs with Min/Max Residuals:
   Minimum (Case 31): (ŷ,e)=(54.7831,-4.52307)
   Maximum (Case 139): (ŷ,e)=(76.3297,6.01032)

Index-Delta Pairs with |δ|>0.344691:
(12,0.36736)      (31,-0.380147)    (86,0.469826)
(135,-0.37936)    (139,0.487417)    (145,0.50669)
```

Looking at these graphs, I think that we are safe to assume normally distributed errors for this data. From the first graph, we don't see any residuals jump out from what we would expect from a normally distributed model. Furthermore, from the second graph, we can see that the size of the residuals don't really change based on the predicted size of y. If anything, we might be a little bit worried about some high leverage points, as we can see from the index/delta pairs. Finally, our predicted model did a fairly good job of explaining the relationship between height, weight, sex, and LBM. This means that our model leaves very little room for other factors that could

To summarize, it appears that there is a fairly strong relationship between height, weight, sex, and lean body mass. From part B of this analysis, we saw that height has a fairly strong (>0.7) correlation with LBM. Additionally, it appeared that men also had higher LBM measures on average. In part C, we saw that people's weight had an even stronger correlation (>0.9) with LBM than weight. From part D, we saw even greater relationships between sex, height, weight, and LBM. Height, weight, and sex all had statistically significant impacts on LBM measures, and these impacts varied by sex. As we can see from the following two equations from part D, height and weight both had a greater positive correlation with LBM among males than among females.

```
f[x1, x2, 0] (* Male Equation *)
```

$$-10.1506 + 0.142109\, x1 + 0.704192\, x2$$

```
f[x1, x2, 1] (* Female Equation *)
```

$$2.00329 + 0.0995781\, x1 + 0.526759\, x2$$

In this part of the analysis, we could see that height, weight, and sex could explain virutally all (~97.7%) of the LBM variation in this data. In part E of the analysis, we saw further evidence for differences between the sexes as with the same height and weight, a man was predicted to have roughly 9 kilograms more of LBM than a woman. Finally, as mentioned earlier in this section, we can be fairly sure of the validity of our model because of the good behavior of our residuals. Thus, we can safely conclude that being male, being heavier, and being taller all have positive correlations with lean body mass. Furthermore, these correlations differ in nature between men and women.