Countermovement Vertical Jump

Presented By

Mina A. Eskandrous

IDEA

- Here we focus on anaerobic exercise which is a short-lasting, high intensity activity in which the body's demand for oxygen exceeds the oxygen supply available. During anaerobic exercises Lactic-acid, which is a by-product of producing energy, accumulates in the blood causing fatigue, and the purpose of such exercise is to make the body more efficient in handling the acid by producing a buffer to delay the fatigue. We will examine the countermovement vertical jump exercise digitally to determine the maximum height, exerted force, and peak power.

IDEA (CONT.)

- The importance of this test is derived from its simplicity and from the powerful results it outputs. Recently the USC athletics department requested a digital way to perform the test which indicates a potential market for professional athletes. Additionally, the device would be useful for Physical Therapists to examine the progress of their patients.

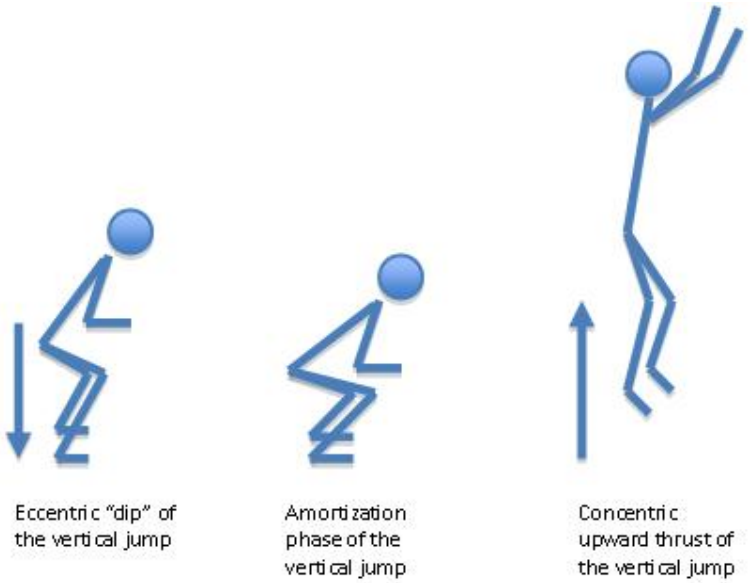
CONCEPT

- Using simple physics laws and the aid of an accelerometer during a one-dimensional vertical jump, the acceleration, velocity, and position can be easily measured. From these data the Ground Reaction Force and the power can be calculated.

CONCEPT (CONT.)

- Using the accelerometer, we can measure acceleration and using EQ.1 & 2 listed below we can find Velocity and Position.

  - $V=V_0 + at$ (EQ.1)
  - $X=X_0 + V_0t + \frac{1}{2} at^2$ (EQ.2)



SAMPLE CODE

- % to find the maximum 2^n power that fits, so that we can take fft

```
n=0;
while (2^n)>length(timet1)
    n=n+1;
end
n=n-1;
nsample=2^n;
```

Code to Find Velocity and Position

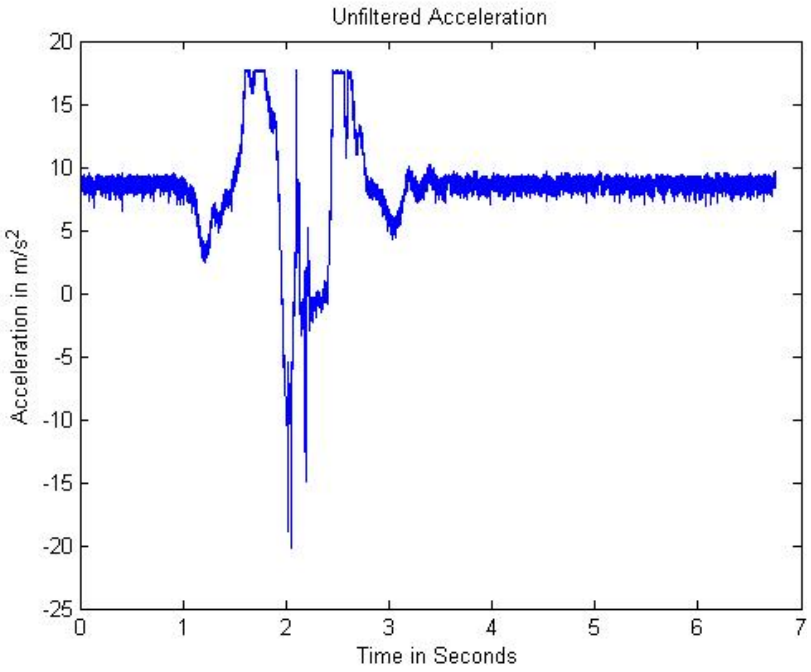
- After taking the Fast Fourier Transform (FFT) and multiplying by a Band-Pass filter to supress noise and include only the desired frequencies we performed the double integration.

- %Double Intergration

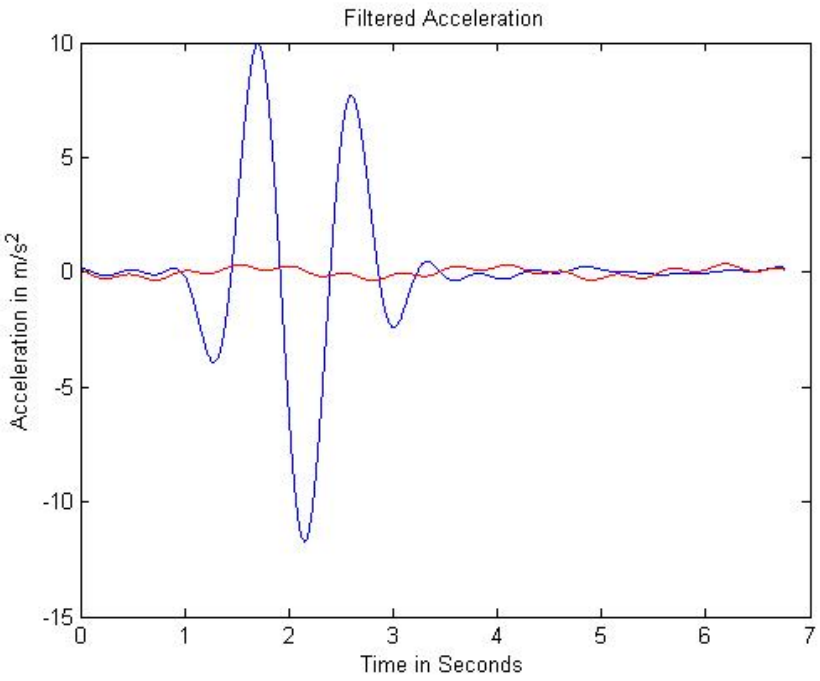
```
for i=1:(nsample)-1
    yvelo(i+1)=yvelo(i)+((reyaccelj(i+1))*steptime);

    ypos(i+1)=ypos(i)+(yvelo(i)*steptime)+(.5*(reyaccelj(i
    +1))*(steptime^2));
end
```

Unfiltered and Filtered Y-accel

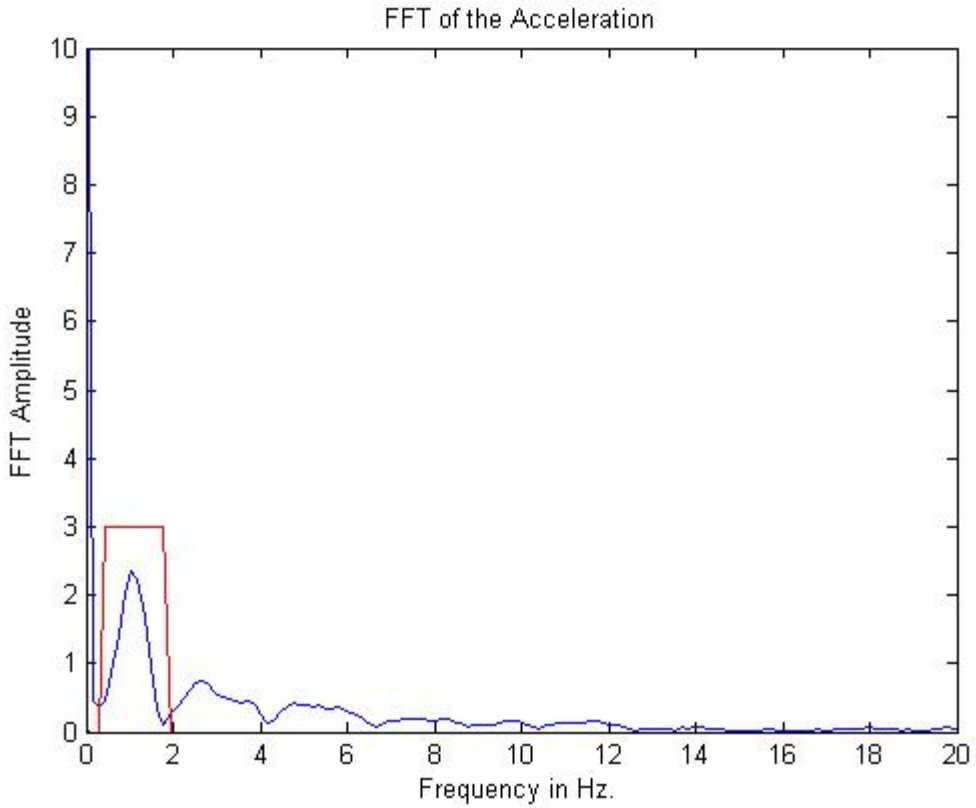
Unfiltered



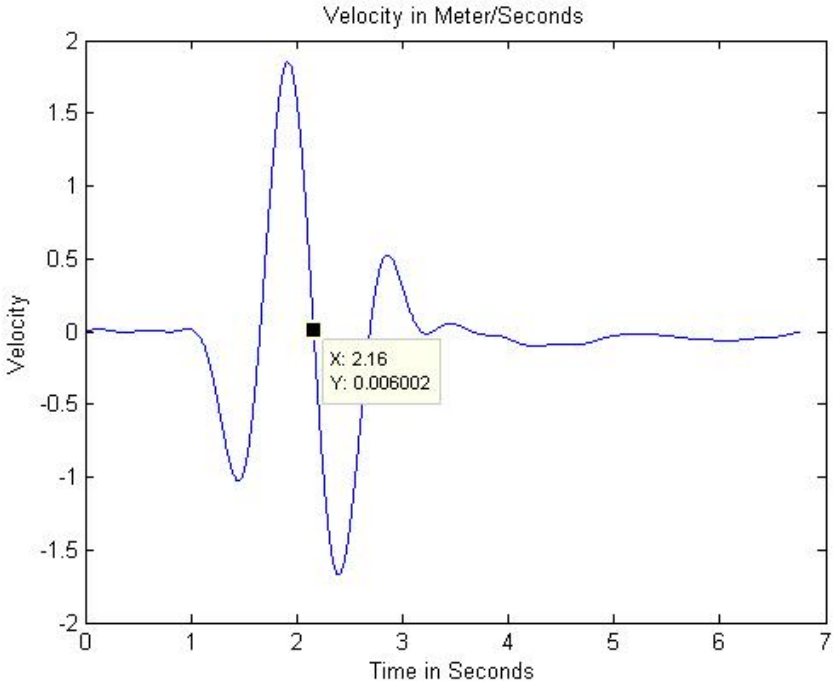
Filtered

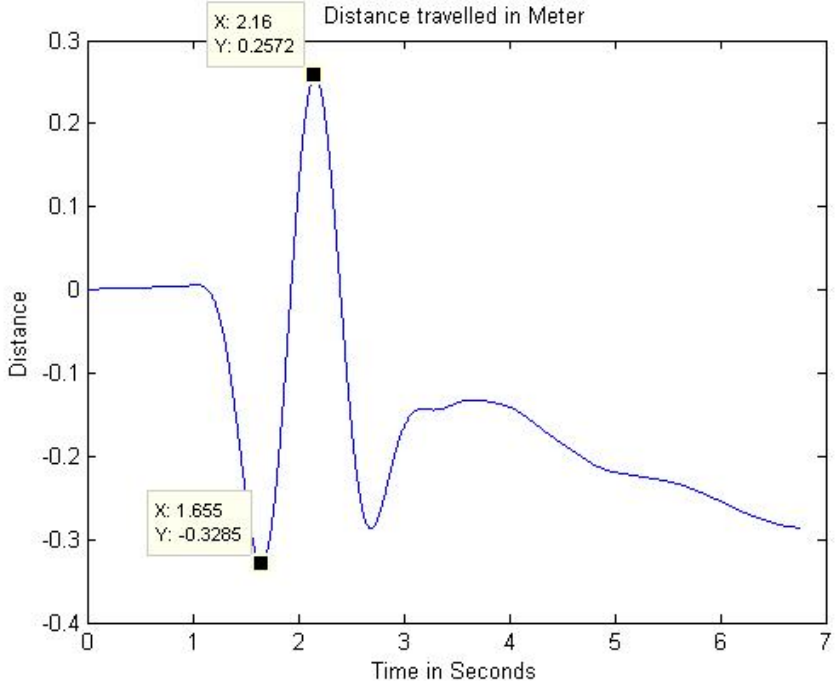


Frequencies and Filter



Velocity and Position Vs. Time





FINDING THE FORCE

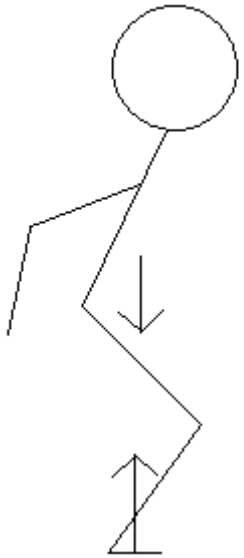
- From Newton's Law

$$\Sigma F = ma \quad \text{(EQ. 3)}$$

the external forces acting on the body are:

The bodies weight (W)

The ground Reaction Force (R)



FINDING THE FORCE

$\Sigma F = ma$

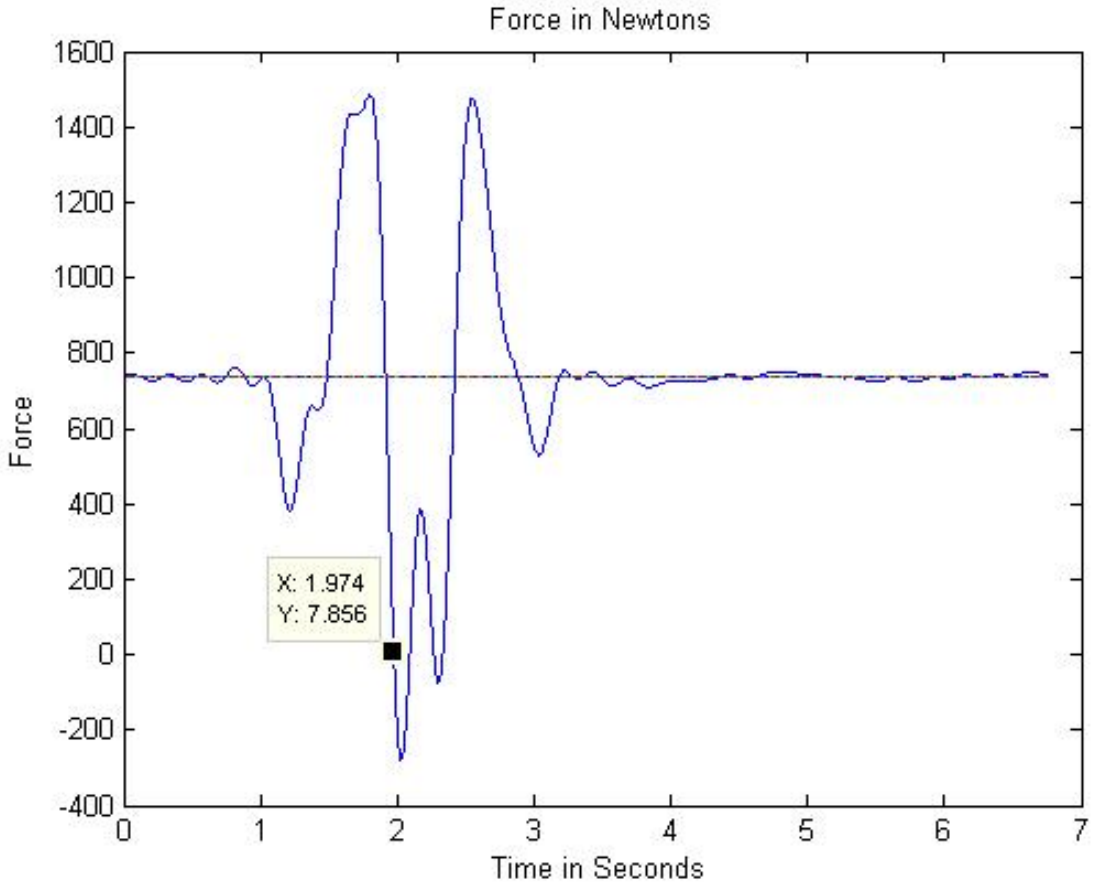
R-W = ma

R = m (a+g)

Power = Force*Velocity

```
for g=1:nsample
    jforce(1,g(t))=mass*(reyaccelj(1,g)+9.8);
    jpower(1,g(t))=(((jforce(1,g))-(mass*gravaccel))*yvelo(1,g));
end
```

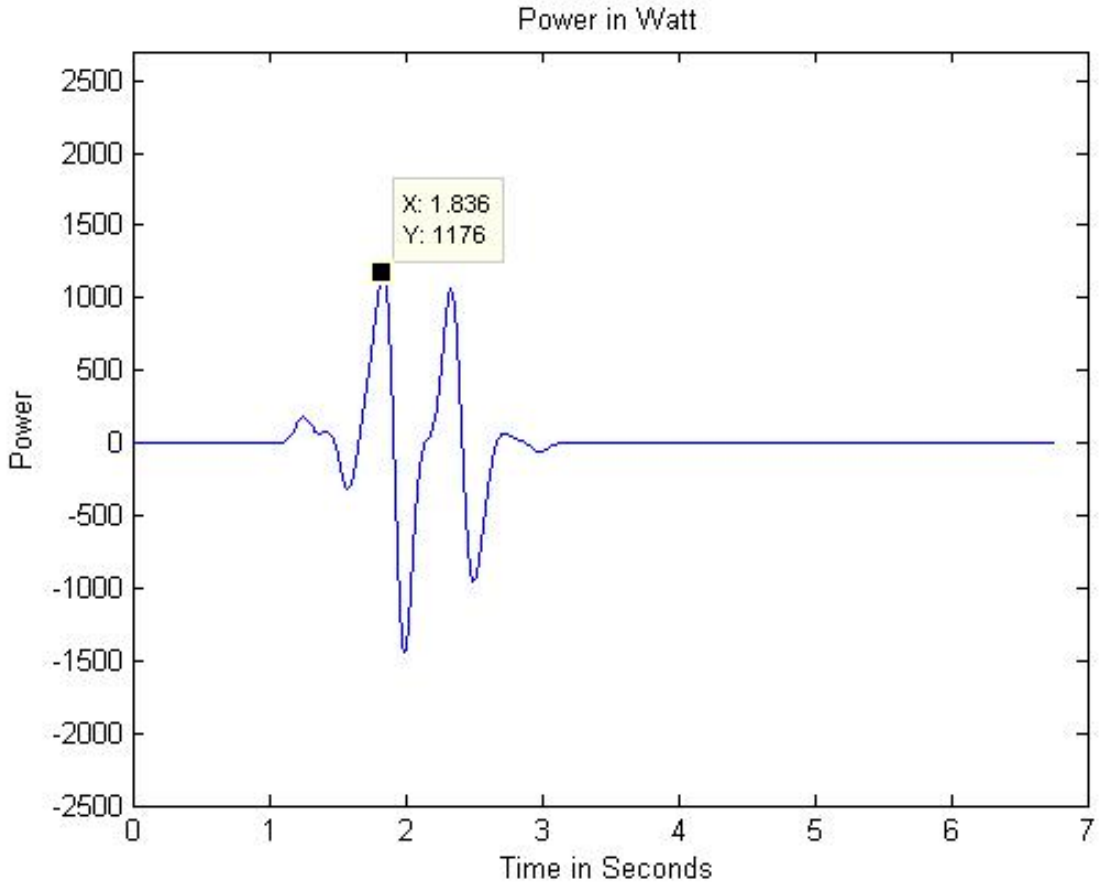
Force Vs. Time



Analyzing the Force-Time Graph

- The straight horizontal line in the last figure represents the weight of the jumper, for this specific case, it was 735 Newton (75 Kg * 9.8). By analyzing the graph we see the ground reaction force fluctuates above and below the weight, as the jumper is 'dipping' the reaction force goes below the weight and as the jumper is in the propulsion phase his reaction force exceeds his weight. The area between the reaction force and the weight in the propulsion phase represents the force impulse applied by the jumper.

POWER


Power in Watt
X: 1.836
Y: 1176
Power
Time in Seconds
2500
2000
1500
1000
500
0
-500
-1000
-1500
-2000
-2500
0
1
2
3
4
5
6
7

RESULTS

height =

0.2350

lowest =

-0.3287

peak_power =

1.1761e+003

avg_abs_power =

102.8281

Marketing (Cost to Produce)

Items	Quantity	Digi-key part #	Price
3-D accelerometer	1	497-6969-1-ND	7.63
300° Gyroscope	1	497-10138-ND	9.55
Microcontroller	1	P8X32A-Q44-ND	7.99
EEPROM [1]	1	24LC256-I/MF-ND	1.62
LED Power/ Heart Beat	1	511-1287-1-ND	0.31
USB MiniB conn	1	A31727CT-ND	1.29
3.3V Regulator [2]	1	576-1135-ND	2.23
Miscellaneous [3]			5
Cost of the Board [4]			20
Total 1-D			**46.07**
Total 3-D			**55.62**

Addition of Gyroscope

- One important addition to the current system is the gyroscope; which is device that measures orientation based on the principle of conservation of angular momentum. The advantageous achieved by including the gyroscope is that instead of having a one-dimensional system, we now have a three-dimension one.