Physics 140 – Fall 2007

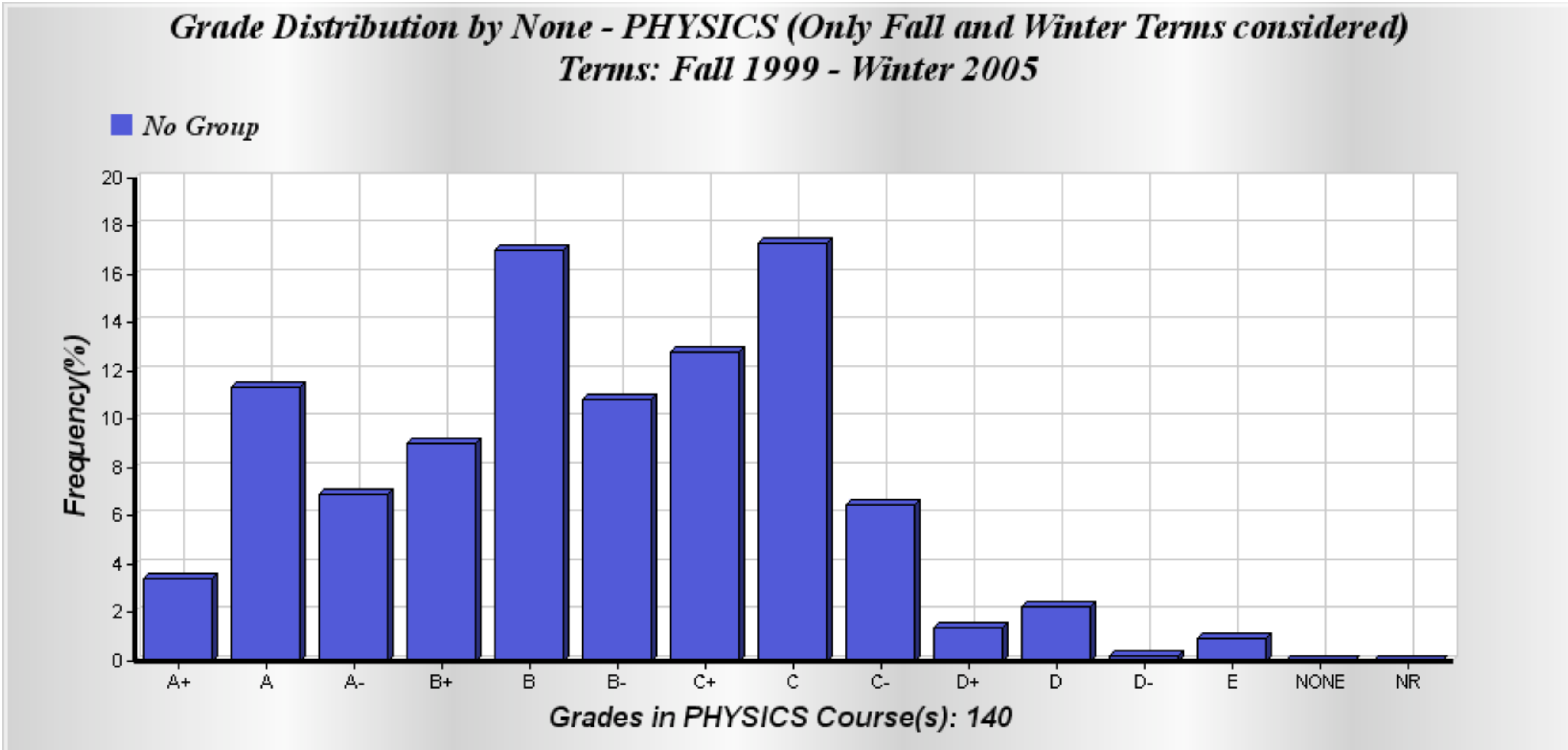
lecture #9: 2 Oct

My grade in high school physics was

1. A
2. B
3. C
4. D
5. I invoke my 5th amendment rights…
6. I didn’t take HS physics

The grade I expect to receive in this class is

1. A
2. B
3. C
4. D
5. none of the above…



Grade Distribution by None - PHYSICS (Only Fall and Winter Terms considered)
Terms: Fall 1999 - Winter 2005
No Group
Frequency(%)
20
18
16
14
12
10
8
6
4
2
0
A+
A
A-
B+
B
B-
C+
C
C-
D+
D
D-
E
NONE
NR
Grades in PHYSICS Course(s): 140

Where are you from?

1. Ann Arbor
2. Michigan palm
3. Michigan UP
4. USA(outside MI), E of Mississippi river
5. USA(outside MI), W of Mississippi river
6. Outside USA

Spring Force and Work

An object attached to a spring that is displaced an amount x along its length (positive x is stretched, negative x compressed) feels a force

$$F = -kx$$

where the minus sign indicates that

the direction of the force is opposite that of the displacement.

The *work done on the object as the spring relaxes back to* its rest position displacement after initially being displaced by an amount x, *is a positive quantity* given by the integral

$$W = \int_x^0 F(x')dx' = -\tfrac{1}{2}kx'^2 \Big|_x^0 = \tfrac{1}{2}kx^2$$

More generally, the work between initial and final displacements is

$$W = \int_{x_i}^{x_f} F(x')dx' = -\tfrac{1}{2}kx'^2 \Big|_{x_i}^{x_f} = \tfrac{1}{2}kx_i^2 - \tfrac{1}{2}kx_f^2$$

A bungee jumper of mass m falls from a tower of height h tethered to a light bungee cord with spring constant k and relaxed length s. Which of the following correctly ensures that the jumper doesn't end up eating pavement?

1. $ks^2 > 2mgh$
2. $k(h-s)^2 > 2mgh$
3. $kh^2 > 2mg(h-s)$
4. $k(s-h)^2 < 2mgh$
5. $k(h-s)^2 > 2mgs$

Power

The rate at which forces do work defines the *power*

average $P_{avg} = \Delta W / \Delta t$

instantaneous $P = dW / dt$

The SI unit of power is the ***Watt*** (1 W = 1 J/s).

When work is done by a constant force $\boldsymbol{F}$ on a system moving with velocity $\boldsymbol{v}$, the instantaneous power applied to the system by this force is given by the scalar product

$$P = \boldsymbol{F} \bullet \boldsymbol{v}$$

This equation follows from the time derivative of the work done.

$$W = \boldsymbol{F} \bullet \boldsymbol{d}$$

A sports car accelerates from zero to 30 mph in 1.5 s. Assuming that the power of the engine is independent of the velocity and that frictional losses are negligible, how long will it take to accelerate from 0 to 60 mph?

1) 2 s
2) 3 s
3) 4.5 s
4) 6 s
5) 9 s
6) 12 s

According to wikipedia, the 2006 Bugatti Veyron 16.4 (shown below) is currently the fastest, most powerful, and most expensive street-legal full production car in the world. From a standing start on a level road, it can accelerate to a speed of 100 km/hr in 2.46 s. How large is the maximum, mean acceleration of this car, in terms of g?

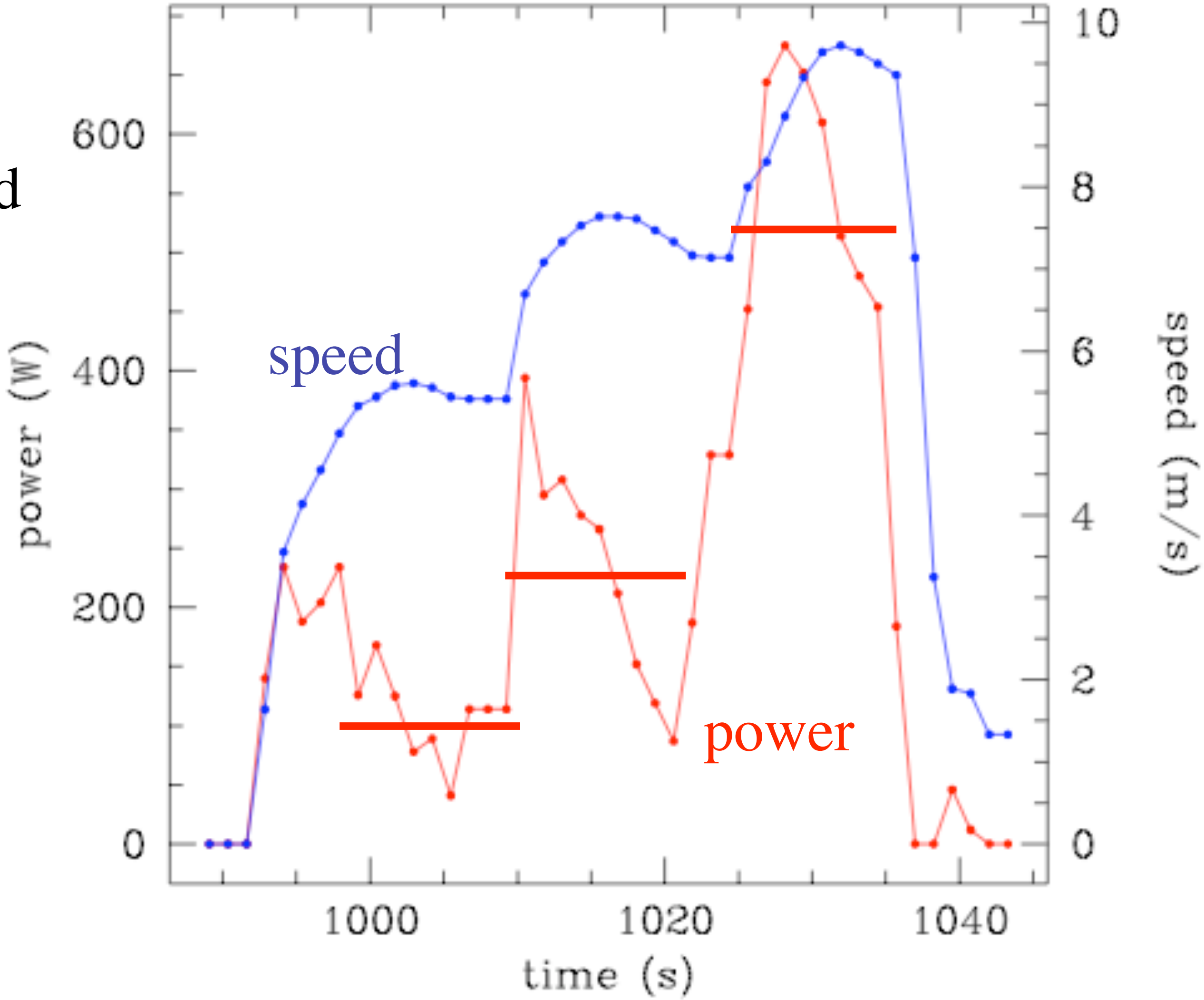
(*answer:* $a_{avg} = 1.15g$)

Dave Winn on Barton Drive, 1 Oct 2005

1D motion in 3 stages: 10, 15, 20 mph (slight uphill)

If power is used only to combat losses due air drag, then we expect

$$P = Dv^3$$



Dave Winn on Barton Drive, 1 Oct 2005

1D motion in 3 stages: 10, 15, 20 mph (slight uphill)

rough estimates of average power from previous graph

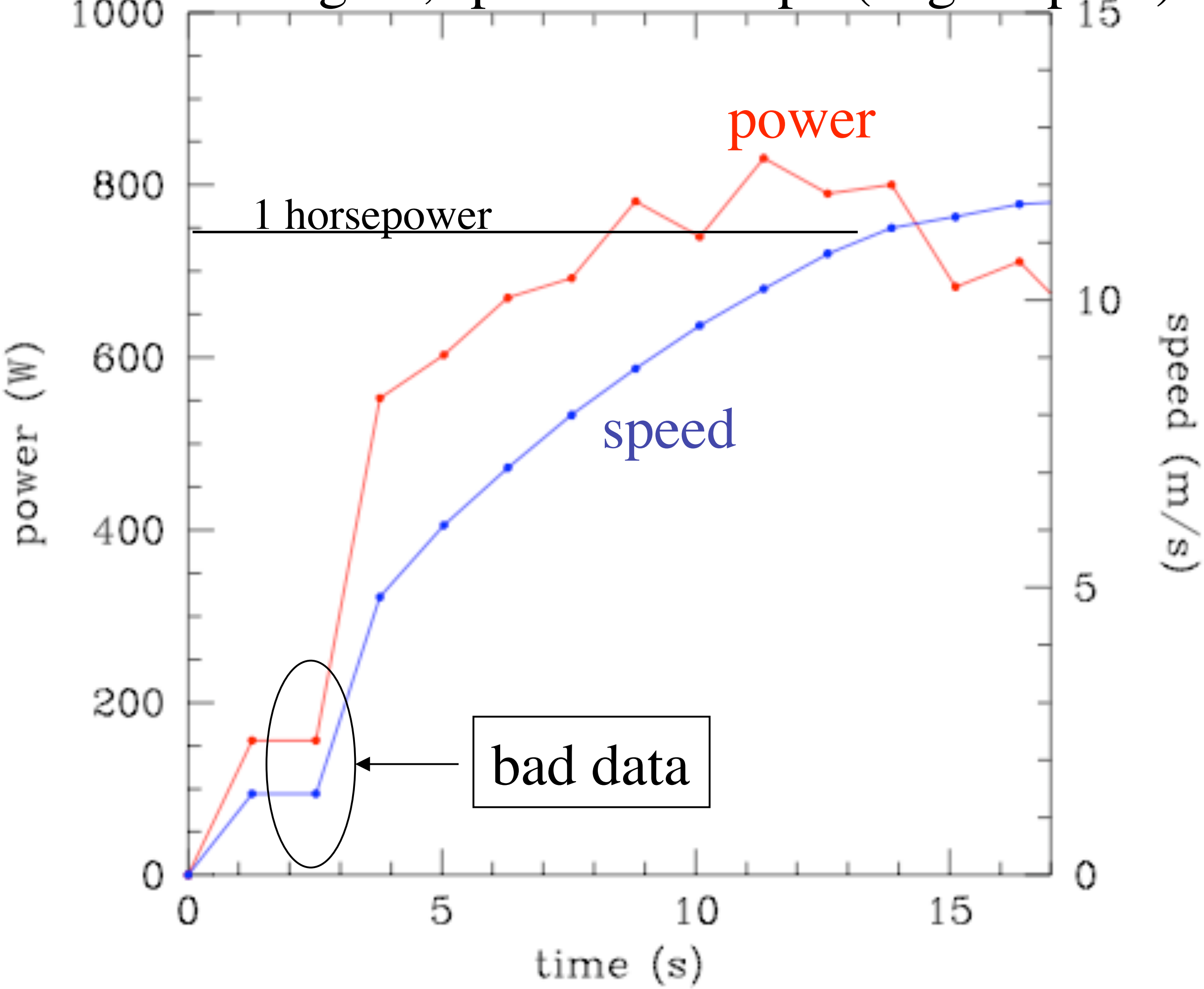
If power is used only to combat losses due air drag, then we expect

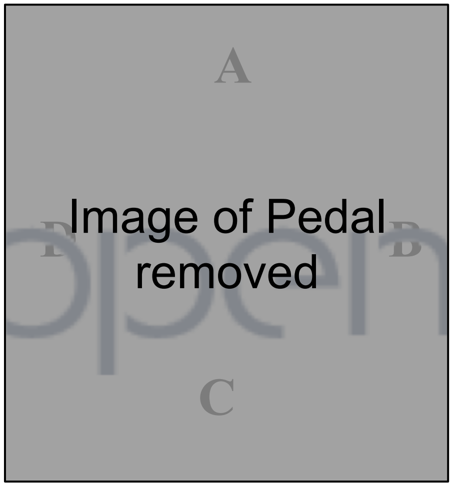
$$P = Dv^3$$

v (m/s)	P (W)	P/v^3 (kg/m)
5.5	100	0.60
7.5	220	0.52
9.5	520	0.61

Prof. Gus on Barton Drive, 1 Oct 2005

1D motion in fixed gear, sprint to 25 mph (slight uphill)





From "Training the Olympic Athlete"
by J. Kearney, Sci American, June 1996, p55.

The arrows in this graphic give the force exerted on the left pedal of a test bicycle by five-time Tour de France winner Lance Armstrong. Assuming that the pedal cadence is nearly constant, rank the points labeled by the power applied at those locations, **least to greatest**

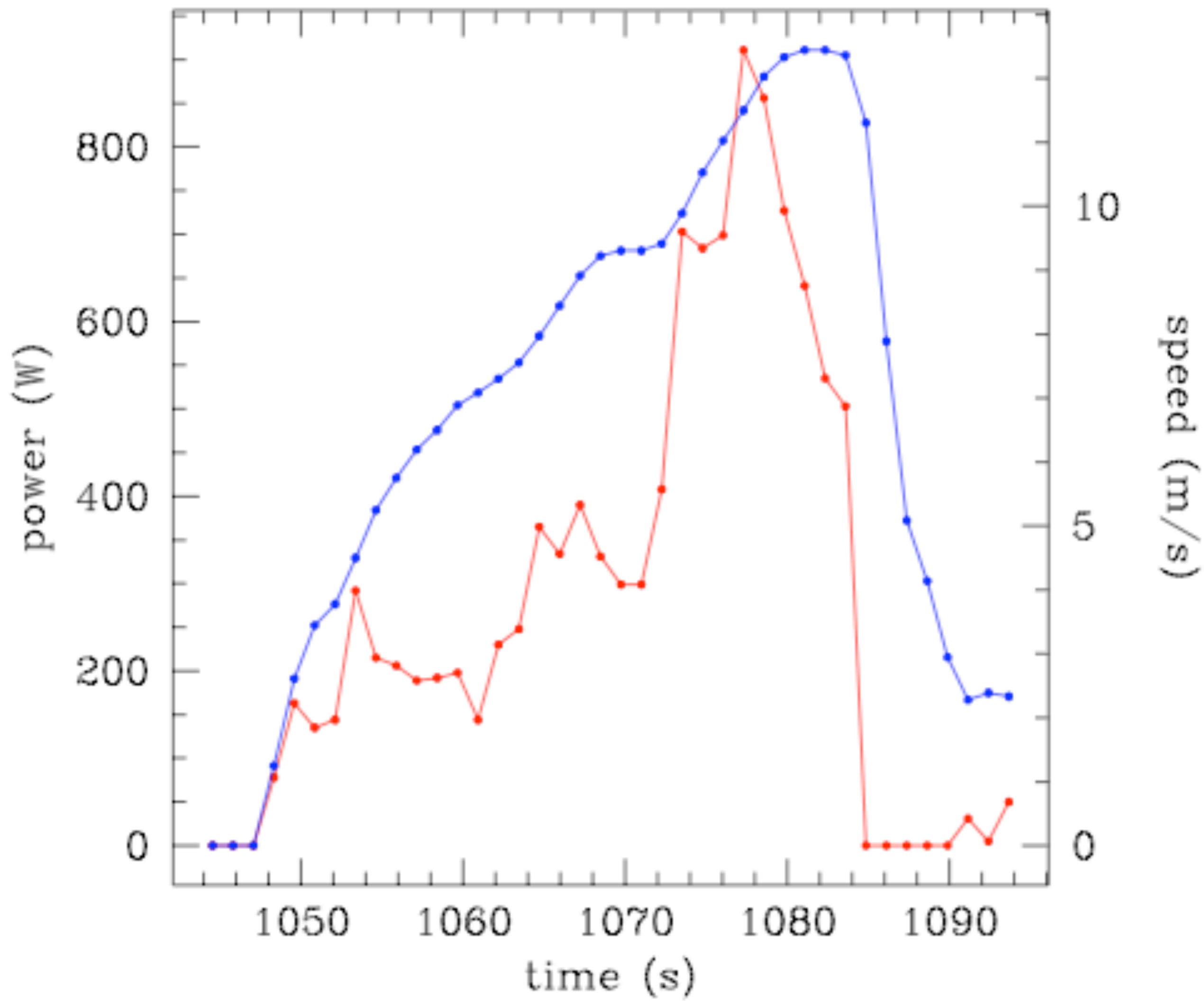
1. A, D, C, B
2. A, D, B, C
3. D, A, C, B
4. D, C, B, A
5. A, B, C, D

Two parcels of equal mass, one of salami and one of cheese, are packed into identical boxes. The boxes are thrown horizontally onto a uniform, level floor and are brought to rest by kinetic friction. If the initial velocity of the salami box is twice that of the cheese, $v_S = 2v_C$, then the ratio of salami/cheese stopping distances (d_S / d_C) is

1. 1
2. 2
3. 1/2
4. 4 ←
5. 1/4

Dave Winn on Barton Drive, 1 Oct 2005

1D motion in 3 stages: 15, 20, 25 mph (slight downhill)



2005: World Year of Physics

www.physics2005.org

The difficulty is that really good music, whether of the East or the West, cannot be analyzed.

Unfortunately, I don't feel I am in a position, on the strength of either my sexual or musical abilities, to accept your kind invitation.
(declining an invitation to participate in a musical event at the First International Congress for Sexual Research in 1926)

Source: The Scientific Monthly (1921)

The New Quotable Einstein, A. Calaprice, ed., Princeton Univ. Press, 2005, pp. 148-9.