ABE 20100
Biological Thermodynamics 1

Module 2
Pressure and Temperature
Absolute vs Relative Scales

Review

- Temperature and Pressure measured on both relative and absolute scales
- Thermodynamic equations (e.g. ideal gas law) require absolute scales
- Gauge pressure – pressure relative to atmospheric (barometric) pressure
- Negative gauge pressures sometimes called “vacuum” – e.g. a vacuum of 25 kPa

Absolute vs Relative Scales

- Absolute scales have a <u>lower bound</u> of zero (no negative values are possible).

- Relative scales compare the measured system to a standard. Values can be <u>both</u> positive and negative (and zero!)

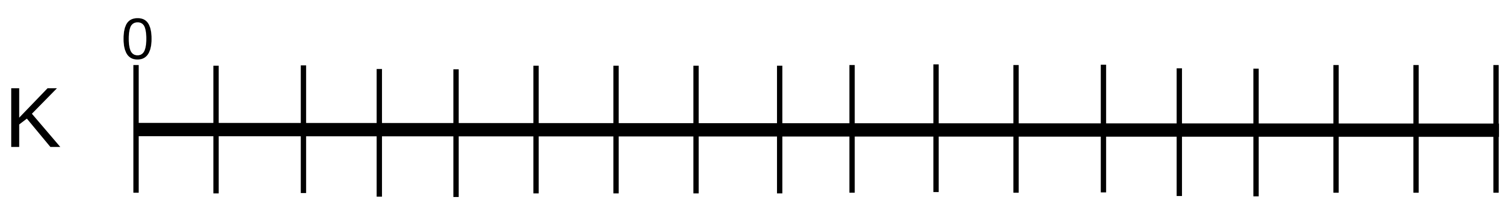
Temperature

Different Units, same <u>increments</u>

Relative	Absolute	Relative	Absolute
°F	°R	°C	K

$\Delta 1°F = \Delta 1°R$

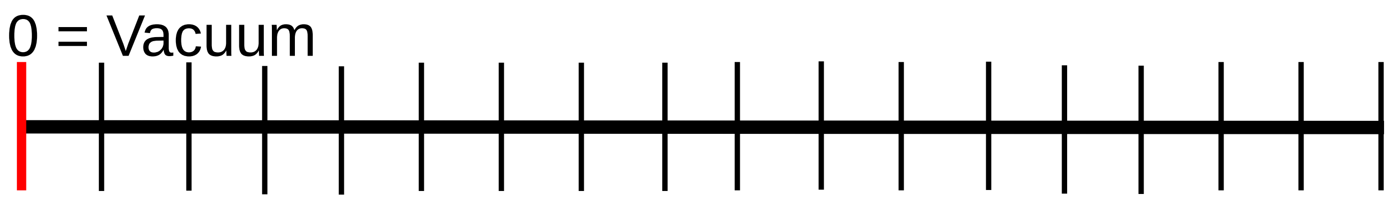
$\Delta 1°C = \Delta 1K$



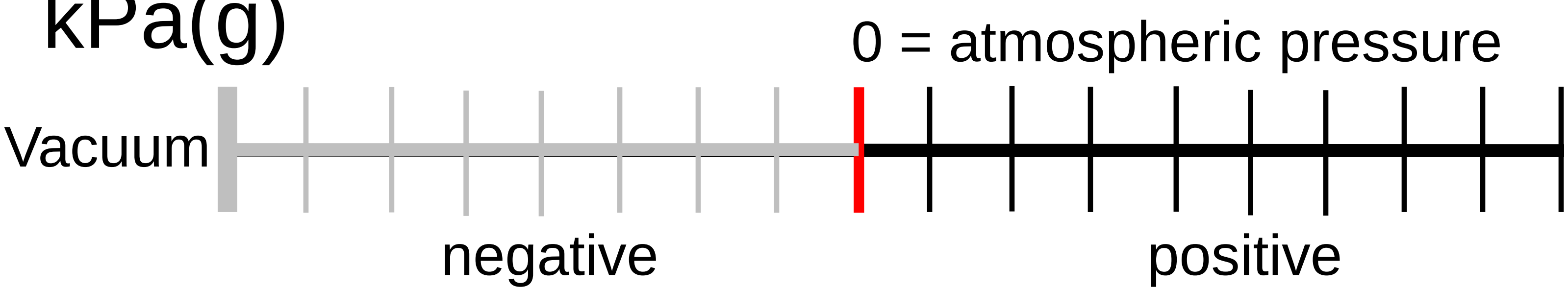
Pressure

- Same Units, need to specify whether absolute or relative

kPa(a)



kPa(g)



Absolute (Thermodynamic) Scales

- Based upon some <u>fundamental</u> physical property of the system

- Both temperature and pressure a function of the <u>kinetic energy of molecules</u>

$$P\ V = n\ R\ T$$

$$R = \frac{PV}{nT}$$

Bun Warmer

A hamburger bun on a conveyor belt passes under an infrared lap. The temperature of the bun increases 23°F during this process.

What is the temperature change in the bun in K?

Fahrenheit vs. Celsius

$$T(°F) = 1.8T(°C) + 32$$

Kelvin vs. Celsius

$$T(K) = T(°C) + 273.15$$

Change in temperature = 23°F

= Final T (23°F) – Initial T (0°F)

Change in temperature = 23°F

= Final T (23°F) – Initial T (0°F)

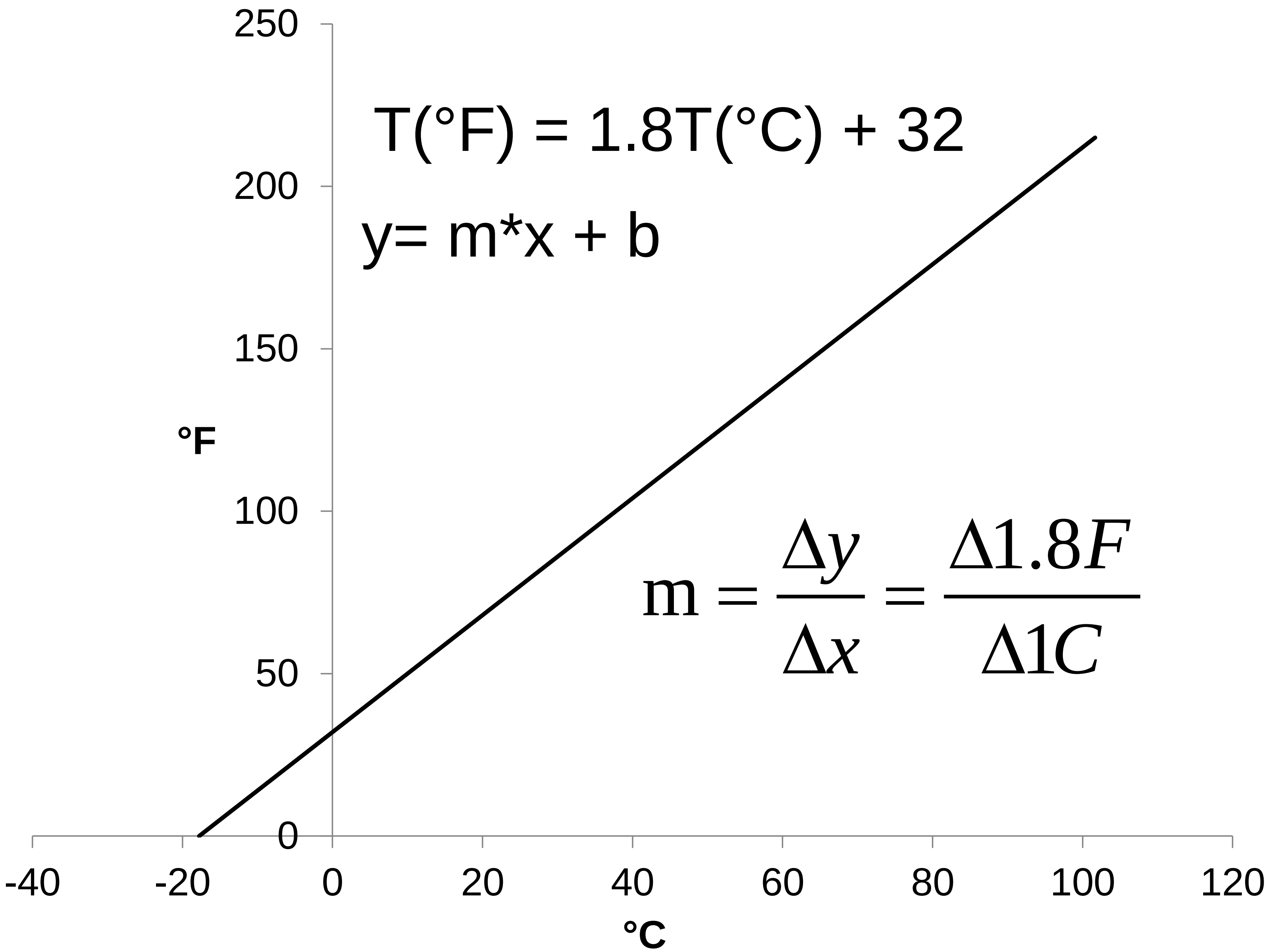
$$=\left(\frac{23-\cancel{32}}{1.8}\right)-\left(\frac{0-\cancel{32}}{1.8}\right)$$

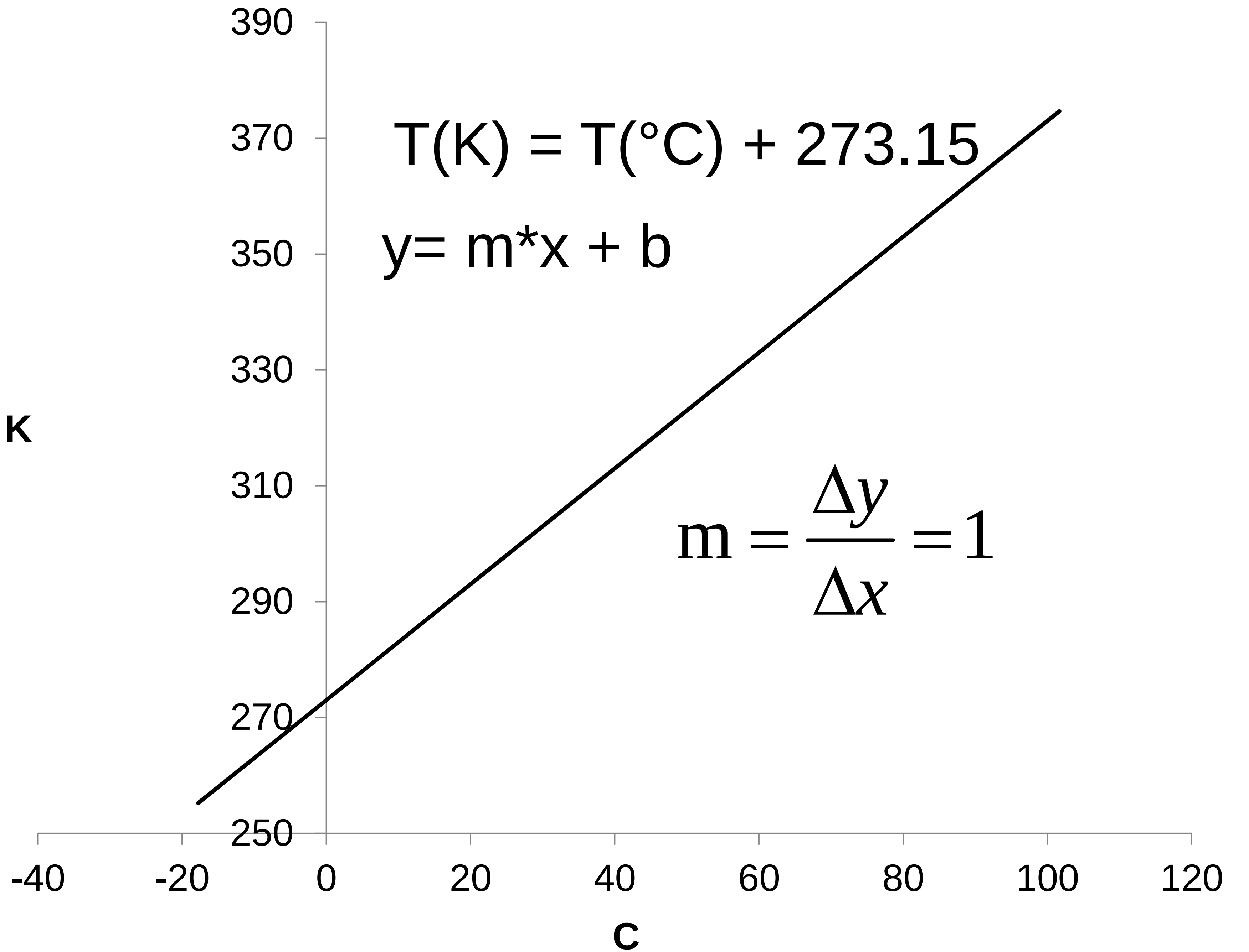
$$=-5^{o}C--17.78^{o}C$$

$$=(-5^{o}+27\cancel{3}.15)\,\mathrm{K}-(-17.78^{o}+27\cancel{3}.15)$$

$$=13\,\mathrm{K}$$

$$=\left(\frac{23}{1.8}\right)$$


T(°F) = 1.8T(°C) + 32
y= m*x + b
$m = \frac{\Delta y}{\Delta x} = \frac{\Delta 1.8F}{\Delta 1C}$
°F
250
200
150
100
50
0
-40
-20
0
20
40
60
80
100
120
°C


T(K) = T(°C) + 273.15
y= m*x + b
m = Δy/Δx = 1
K
C
390
370
350
330
310
290
270
250
-40
-20
0
20
40
60
80
100
120

Apollo 1

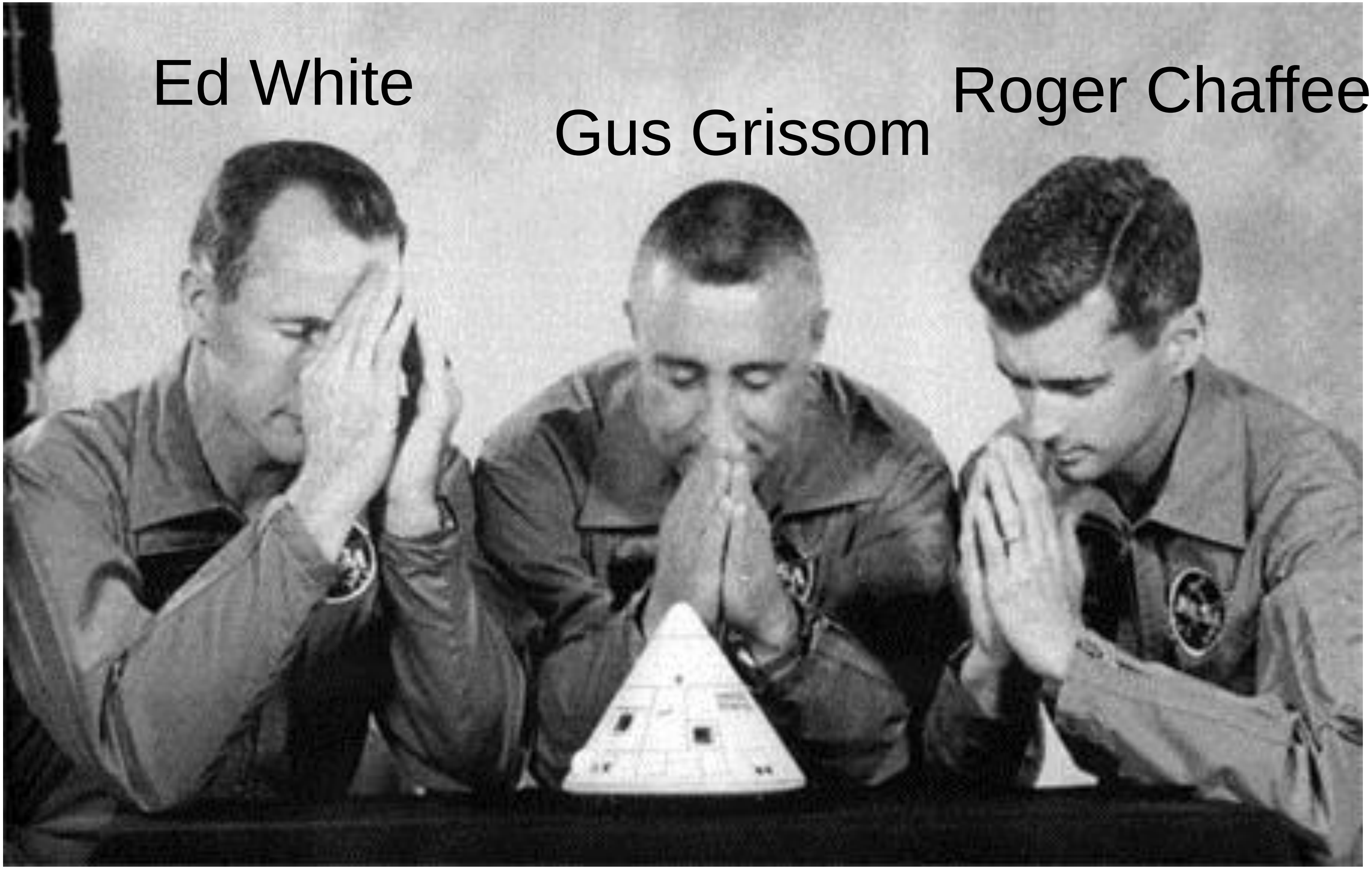
The Apollo command module was designed to hold an air pressure of 2.0 psia against the vacuum of space.

To what pressure (psia) must the capsule be pressurized for a test on the launch pad in Florida to correctly simulate what would happen in orbit?

- In space, the difference in pressure between inside and outside the capsule = 2.0 psi

- To simulate this on the ground in Florida, the capsule must be pressurized to atmospheric + desired pressure

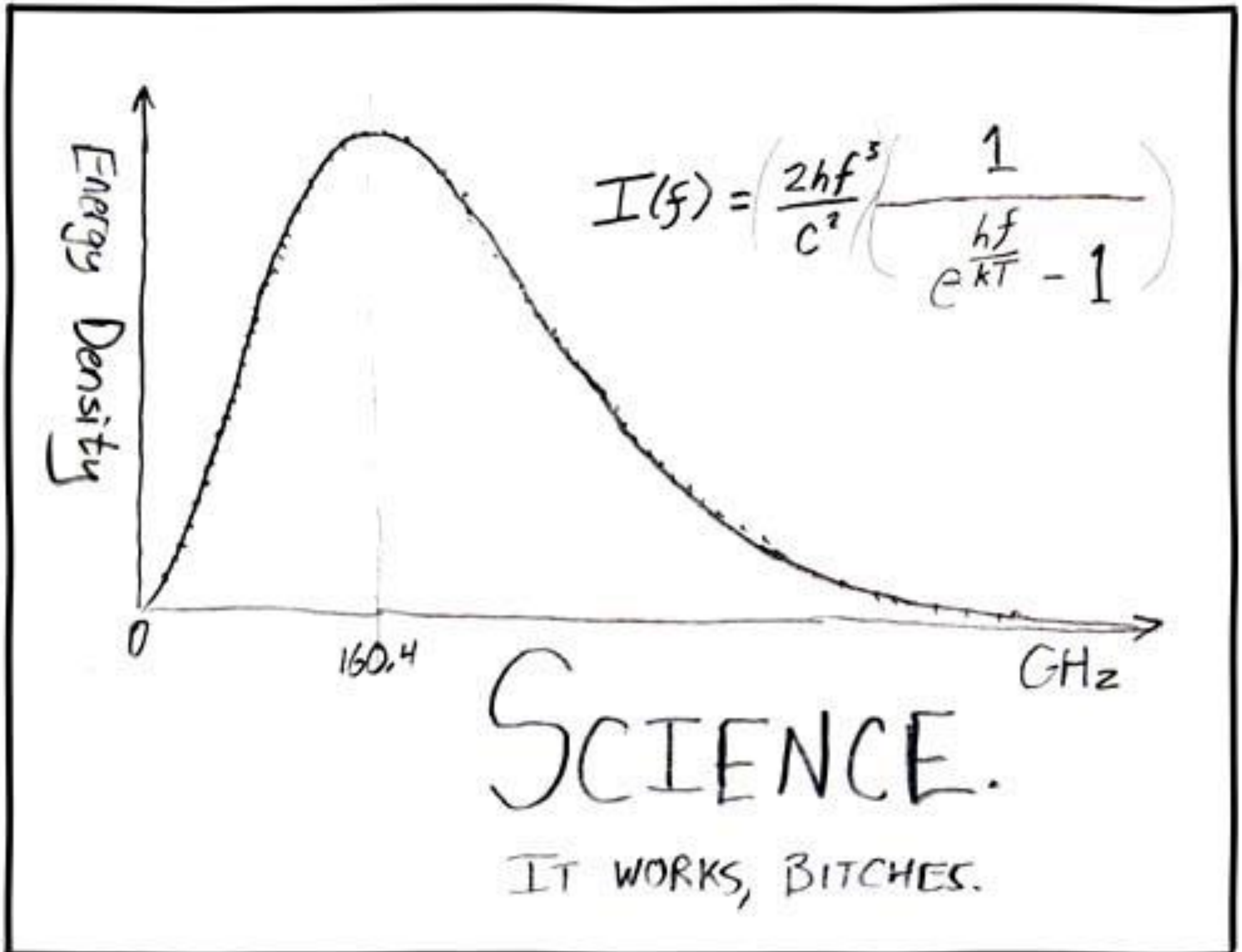
= 14.7 + 2.0 = 16.7 psi(a).


Ed White
Gus Grissom
Roger Chaffee

“Plugs Out” Test
January 27, 1967

- Capsule on Saturn V on launch pad
- Astronauts inside
- Capsule disconnected from anything on the ground
- Testing capsule internal power and communication systems
- Pressurized with O2 to make the test a more realistic simulation of orbital conditions
- “Safe test” – no fuel in the rocket, no pyrotechnics (exploding bolts to separate stages, etc.)

Astronaut White's Flight Suit.
Photo Credit — National Archives



http://xkcd.com/54/

Ideal Car Tires

- Your car tire has a volume of 4.5 L.
- You measure the pressure as 35 psig
- Your thermometer reads at 82 F

- How many moles of air are in your tire?

R = 0.082057 L atm/(mol K)

$$PV = nRT$$

$$n = \frac{PV}{RT}$$

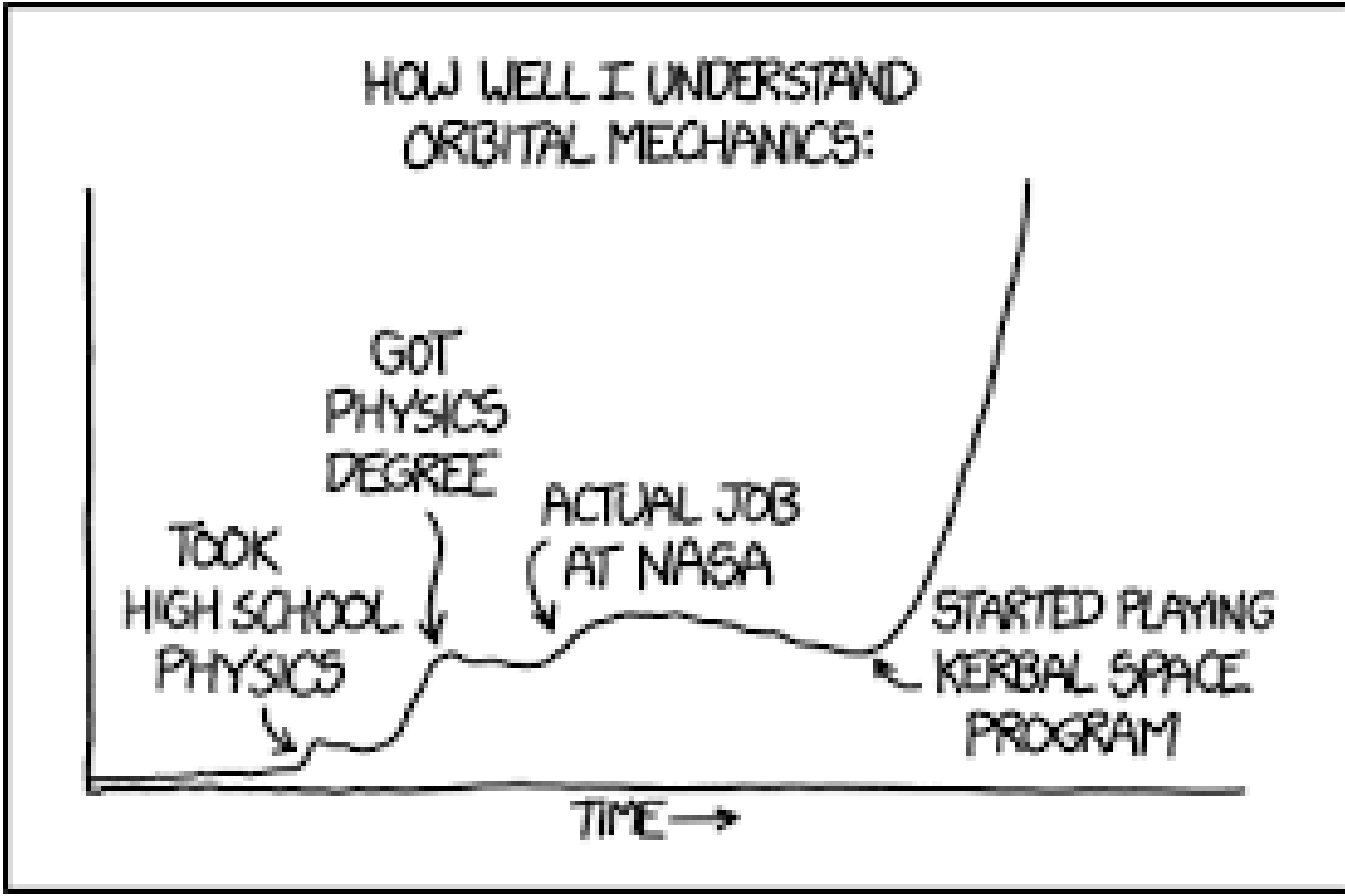
$$T = 82F = 301K$$

$$V = 4.5L$$

$$P = 35\,psig + 14.696 = 49.696\,psia = 3.3816atm$$

$$n = \frac{(3.3816atm)(4.5L)}{\left(0.082057\,{}^{Latm}\!/\!_{molK}\right)(301K)}$$

$$n = 0.62mol$$


HOW WELL I UNDERSTAND ORBITAL MECHANICS:
GOT PHYSICS DEGREE
ACTUAL JOB AT NASA
TOOK HIGH SCHOOL PHYSICS
STARTED PLAYING KERBAL SPACE PROGRAM
TIME →