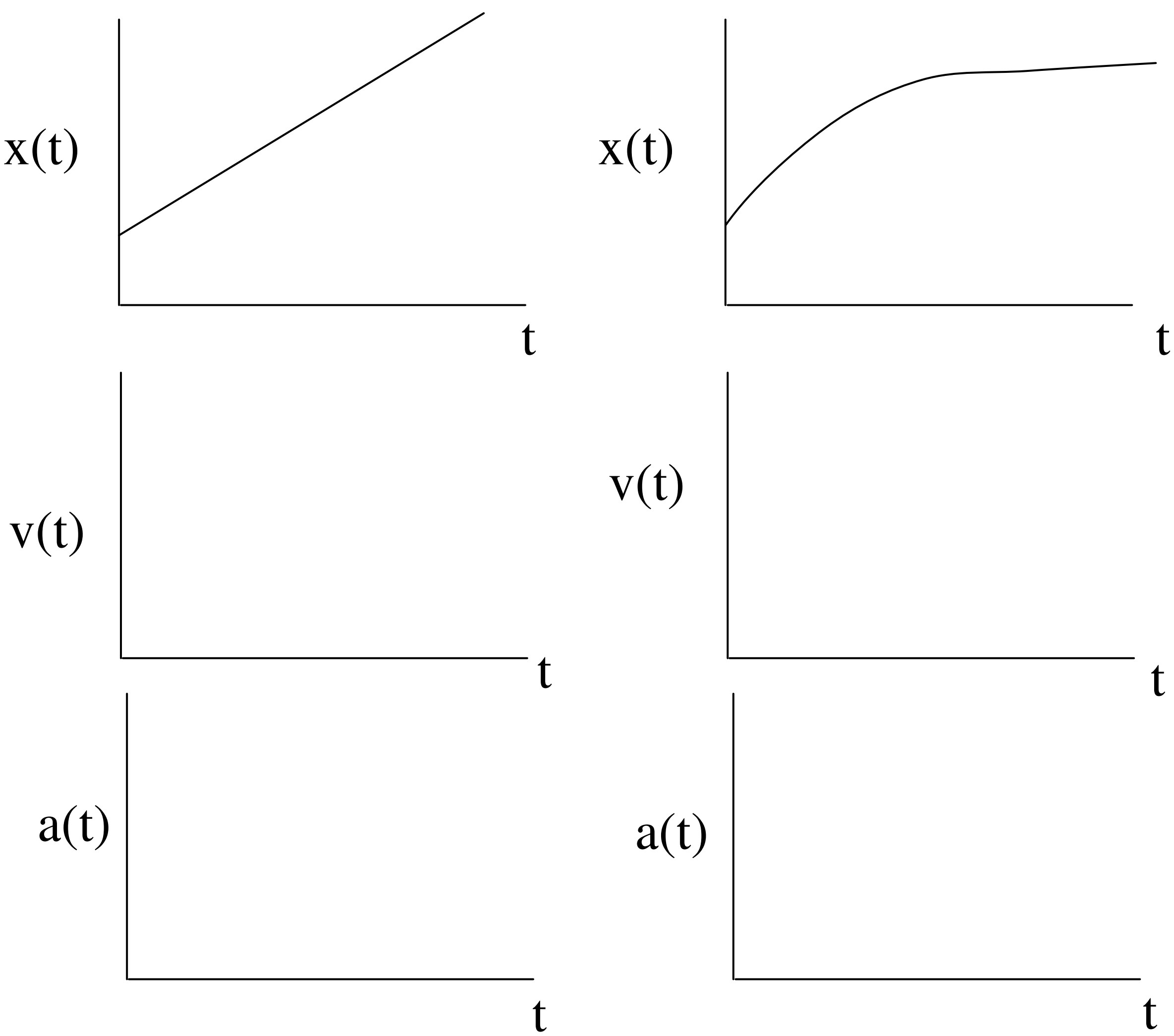
Physics 105 Class 2
ACCELERATION

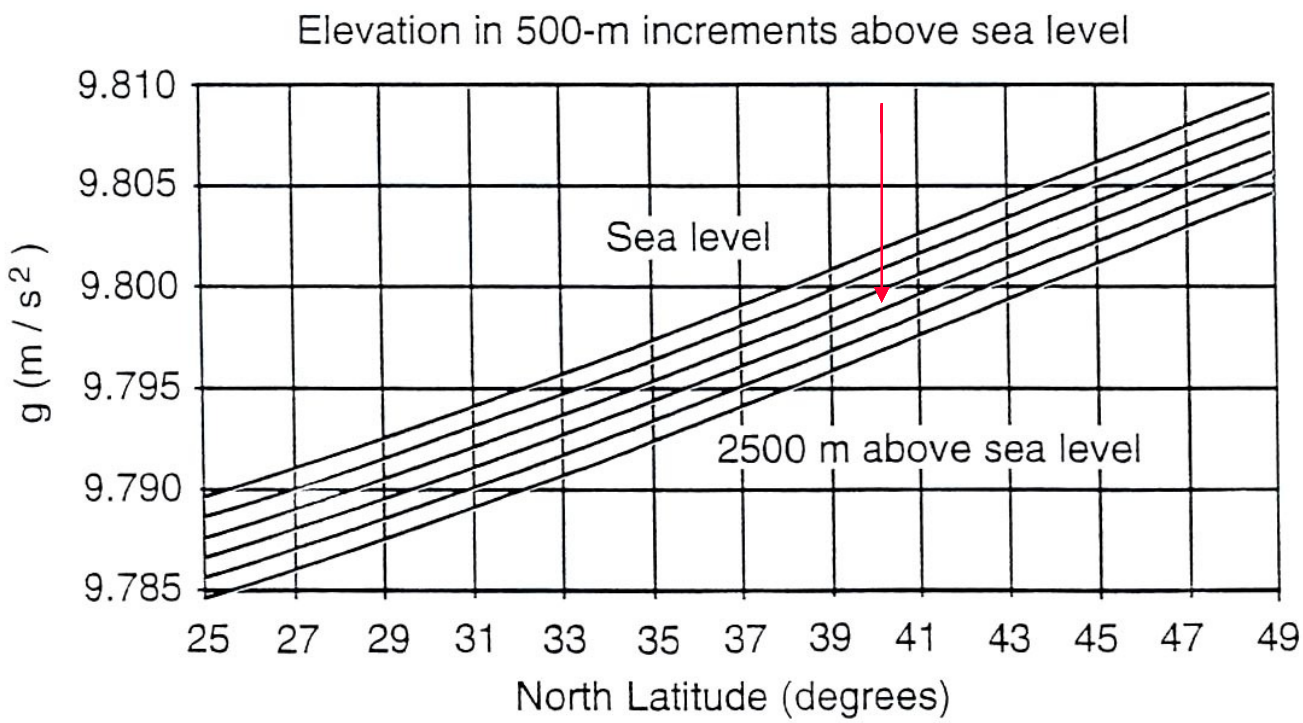
Position: where the object is.
Displacement: change in position.
Velocity: rate of change in position with time: instantaneous velocity is *slope* of x vs t graph.

Acceleration: rate of change in velocity with time: *slope* of v vs t graph.
average acceleration $\langle a \rangle = \Delta v/\Delta t$



Some example accelerations:

a due to gravity near earth: g=9.8 m/s^2 (one “g”)



g near Provo:

Latitude = 40.24° N
Elevation = 4660ft = 1420m
***g* = 9.799 m/s^2**

Space shuttle: 20 m/s^2 (2-g’s)

Fighter pilots: 5-9 g’s

Air Force Dr. John Stapp

In 1954 he rode the "Sonic Wind" at 623 miles per hour, to a dead stop in 1.4 seconds.   Max a: 45 g's.

To change units – see inside front cover for conversion factors.   <u>1 m/s =2.237mi/h</u>

Car g’s while stopping:

Stopping Distance (feet)	Required Average g's from 100 MPH	Required Average g's from 60 MPH	Required Average g's from 30 MPH
55.6	6.0	2.2	0.5
50	6.7	2.4	0.6
40	8.4	3.0	0.8
30	11.1	4.0	1.0
20	16.7	6.0	1.5
10	33.4	12.0	3.0
5	66.8	24.0	6.0
2	167.0	60.1	15.0
1	334.0	120.2	30.1
0.5	668.0	240.5	60.1
0.333	1002.2	360.8	90.2
0.167	2004.9	721.8	180.4

The goal of a "safe" crash is to stop over a *long time* (distance)

How **strong** do you want your car?

In a collision, different *parts* of the car decelerate with *different* g's.

Actual data from a 35 mph car crash test

Time (MS)	Events
12	initial **folding** of **longitudinal**
16	initial **folding** of **subframe**
21	1st **buckling** of **rails** upper in front of shock tower
35	**engine contacts barrier**: **20 g's on engine**
51	**wheels contact barrier**: **10 g's**
67	maximum dynamic deformation
95	**Person comes to rest: 5 g's**

If you hit the windshield...some parts of you decelerate *before* the rest of you: crushing you

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For motion along a line**, position, displacement, velocity, and acceleration have a <u>direction</u>,**

given by the **sign** (+/-)

or a **description** (left, right, north, south)

Keeping track of signs:

What do we mean by +/- postion?

being on the + or - side of the origin

What do we mean by +/- velocity?

moving toward the + or - direction

What do we mean by +/- acceleration?

the *change* in velocity is in the + or – direction.

Example:

A car moves left at constant speed. ***a*** is ____

A car moving left is slowing down. ***a*** is ____

A car moving left speeds up. ***a*** is ____

Hint: how you can **always** know the direction of ***a***

a and speeding up/slowing down!

- If ***a*** is in same direction **v**→ speeds up
- If ***a*** is in opposite direction **v** → slows down

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Paddle-bunji-ball

P1. What is the direction of the ball's acceleration <u>during the contact</u> (hit) between paddle and ball? (Choose):

1. right
2. left
3. zero ***a***

DQ1. What is the direction of ***a*** of the ball while traveling to the right (and slowing down)? (same choices)

DQ2. What is the direction of ***a*** at the instant the ball is stopped by the elastic and about to start coming back?

P4. What is the direction of ***a*** when the ball is coming back (to the left, and speeding up)?

Sketch v(t) and a(t): include hitting time, traveling to right, traveling to left. Motion to the right is positive, left is negative.

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The text derives the four "Kinematic Equations" for *constant* acceleration.

1) $\mathbf{v = v_o + a\,t}$

2) $\mathbf{x = x_o + \frac{1}{2}(v_o + v)\,t}$ **(from** $\mathbf{\Delta x = \langle v \rangle \Delta t}$ **)**

3) $\mathbf{x = x_o + v_o t + \frac{1}{2} a\, t^2}$

4) $\mathbf{v^2 = v_o^2 + 2a\,(x - x_o)}$

v_o is the velocity at the time you call t=0
x_o is the position at the time you call t=0

You can substitute y for x for vertical motion.

These and other formulas can be taken into the exams

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Example: A sprinter does the 50 m dash in 15 sec, with constant acceleration.   Find:
a) Her average velocity
b) Her final velocity
c) Her acceleration

Draw a **diagram**!
Label with symbols, numbers.
Look for connection with equations.

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A bullet has a speed of 1500 m/s after it is shot from a gun. The gun has a barrel length of 75 cm.

a) What was the acceleration of the bullet?

P5. i) **Draw a picture of the gun, and put numbers and symbols on the picture**

Use symbols: x, x_o v, v_o, a or t

ii) Choose one or two kinematic equations that would give you acceleration.

b) How long was it in the barrel after it was shot?

Example: Throwing a ball straight up---- acceleration directions

While throwing:

While traveling up:

At the very top:

While falling down.

Free-falling objects

acceleration is ______ with direction_________

Example: A rock is thrown upward off a cliff 30 m high, with an initial velocity of 20 m/s.

a) How long does it take to reach the top of its path?
b) What is the velocity just before it hits the ground below the cliff?
c) How long does it take to hit the ground?

- put y for x in the kinematic equations
- choose positive direction and sign of g.
- choose y=0 point

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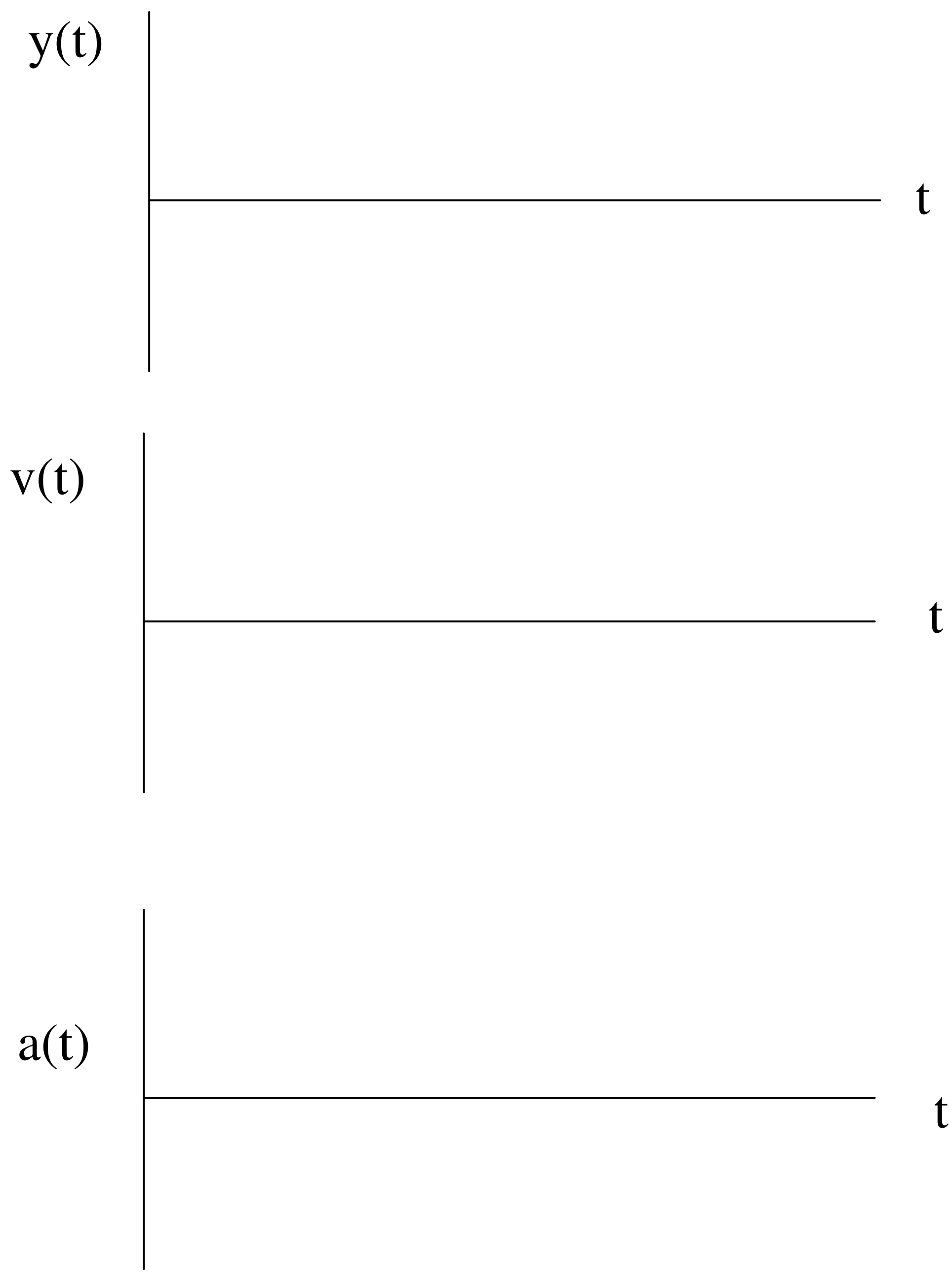
P6. Sketch y(t), v(t) and a(t) for the rock after it was thrown. Put the origin at the ground level



Is a dropped feather in freefall?

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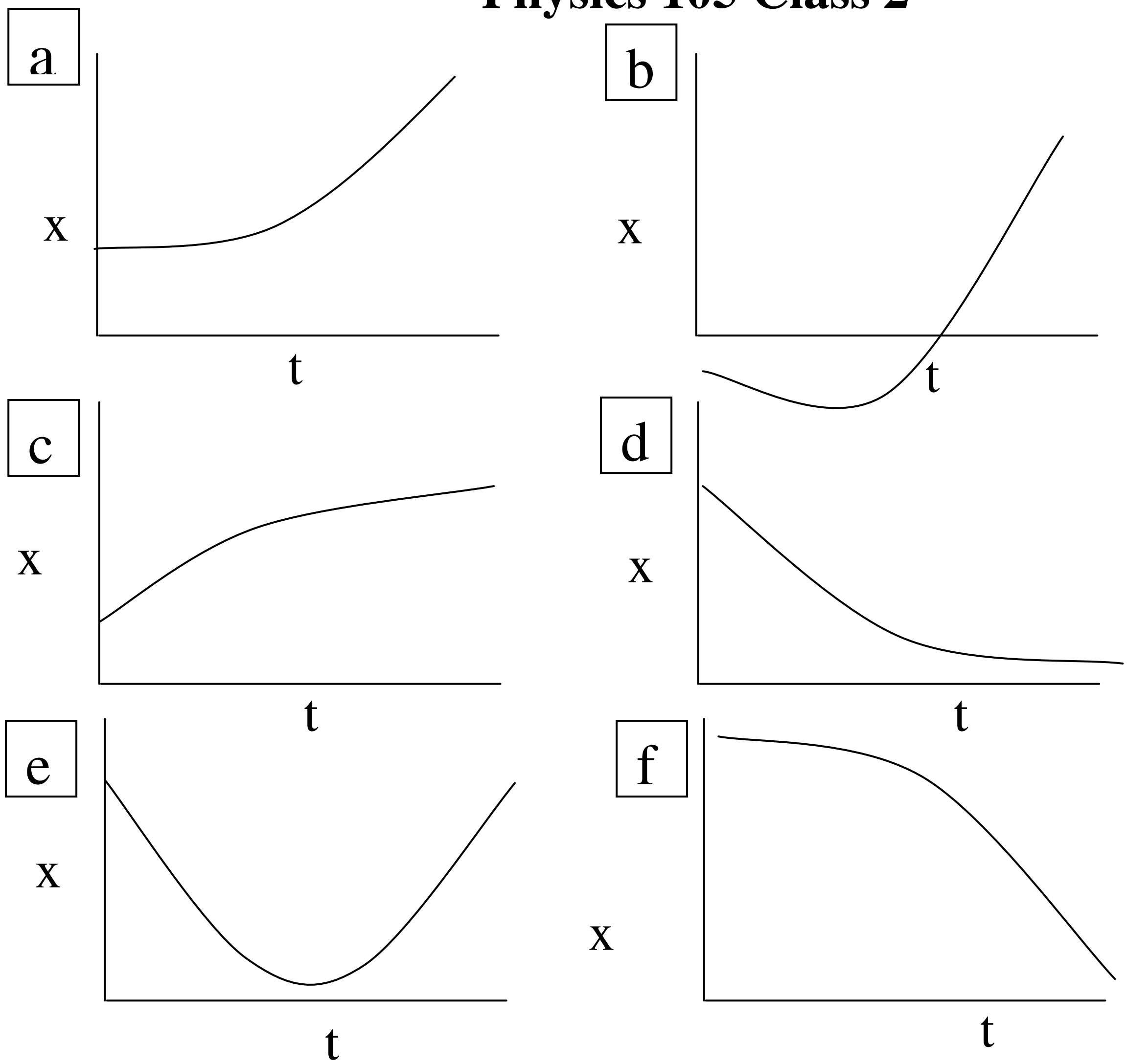

A car moves along a road. There is a lamppost at x = 0. Which x vs t curve describes:

P7. a car **slowing down** as it moves **away** from the lamppost

P8. a car moves **toward** the lamppost, but **slows down** and **turns around** and speeds up

P9. a car **speeding up** as it moves **toward** the lamppost

P10. a car that moves away from the lamppost, turns around and **passes** the lamppost

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HOMEWORK HELPS