San Francisco State University
Department of Earth & Climate Sciences

Name ______________________________
Spring 2018

ERTH 260: Inclass Exercise #9
CAPE and Vertical Velocity

(Due Friday 21 April 2018; 100 points)

You should work together by Tables.

Answer on separate sheet of paper in complete sentences. There should be a clear connection between your answers and the online handouts on CAPE and calculations related to CAPE.

1. The sounding for Fort Worth TX at 0000 UTC on 17 April is given below. The brown dotted line represents a lofted parcel's ascent curve. The Convective Available Potential Energy (CAPE) value for that parcel is indicated in the enclosed box at bottom left, in the upper panel, and outlined in brown. The unit is m^2/s^2.

   The LFC for this parcel is 960 m (~3000 feet) above the ground.

   The conceptual definition of CAPE is that it represents the sum of the upward acceleration due to buoyancy for each level of the atmosphere from the LFC to the EL. Assume that an air parcel is lofted to the LFC and then just one meter above the LFC.

   (a) By visual examination of the sounding and the parcel ascent curve, explain why the greatest buoyancy acceleration experienced by that parcel would occur at around the 500 mb level. (25 points)

   The buoyancy acceleration is given as the fractional difference between the temperature of the air parcel and that of its surroundings at the same pressure elevation.

$$\bar{a} = \frac{-\left(T_e - T_p\right)}{T_e} g$$

   In situations in which there is an LFC, this acceleration is positive (upward) and is directly proportional to the difference in temperature between the lofting air parcel and its surroundings, as given in the numerator of the expression above.

   A visual examination of the Fort Worth sounding and the parcel ascent curve, shows that the largest temperature difference between the parcel

ascent curve and the ELR will be at around 500 mb. Thus, it is at that level that the greatest upward buoyancy acceleration will occur.

(b) Explain why, despite (a), the greatest upward vertical velocity due to buoyancy (sometimes called the "convective vertical velocity) will occur at the EL (which is near 200 mb in this case). (25 points)

CAPE is essentially the summation of the buoyancy accelerations for every level of the atmosphere from the LFC to the EL. As long as there is a buoyancy acceleration upward, the air parcel will continue to accelerate upward. In other words, as the parcel reaches the next elevation it will be given an additional acceleration upward. Thus, the air parcel's upward vertical velocity will continue to increase until it reaches the Equilibrium Level, and its temperature is no longer greater than that of the environment's.

$$CAPE = \left(\sum_{LFC}^{EL} \left[\frac{(T_p - T_e)}{T_e} \right] g \right) \Delta z$$

2. The formula for the convective vertical velocity is

$$w = [2XCAPE]^{1/2}$$

Compute the convective vertical velocity for this case. Show all steps. (25 points)

CAPE = 1542 m^2/s^2

$$w = \sqrt{2 \text{ x } 1542 \text{ m}^2}\text{s}^{-2}$$

$$w = \sqrt{3084 \text{ m}^2}\text{s}^{-2}$$

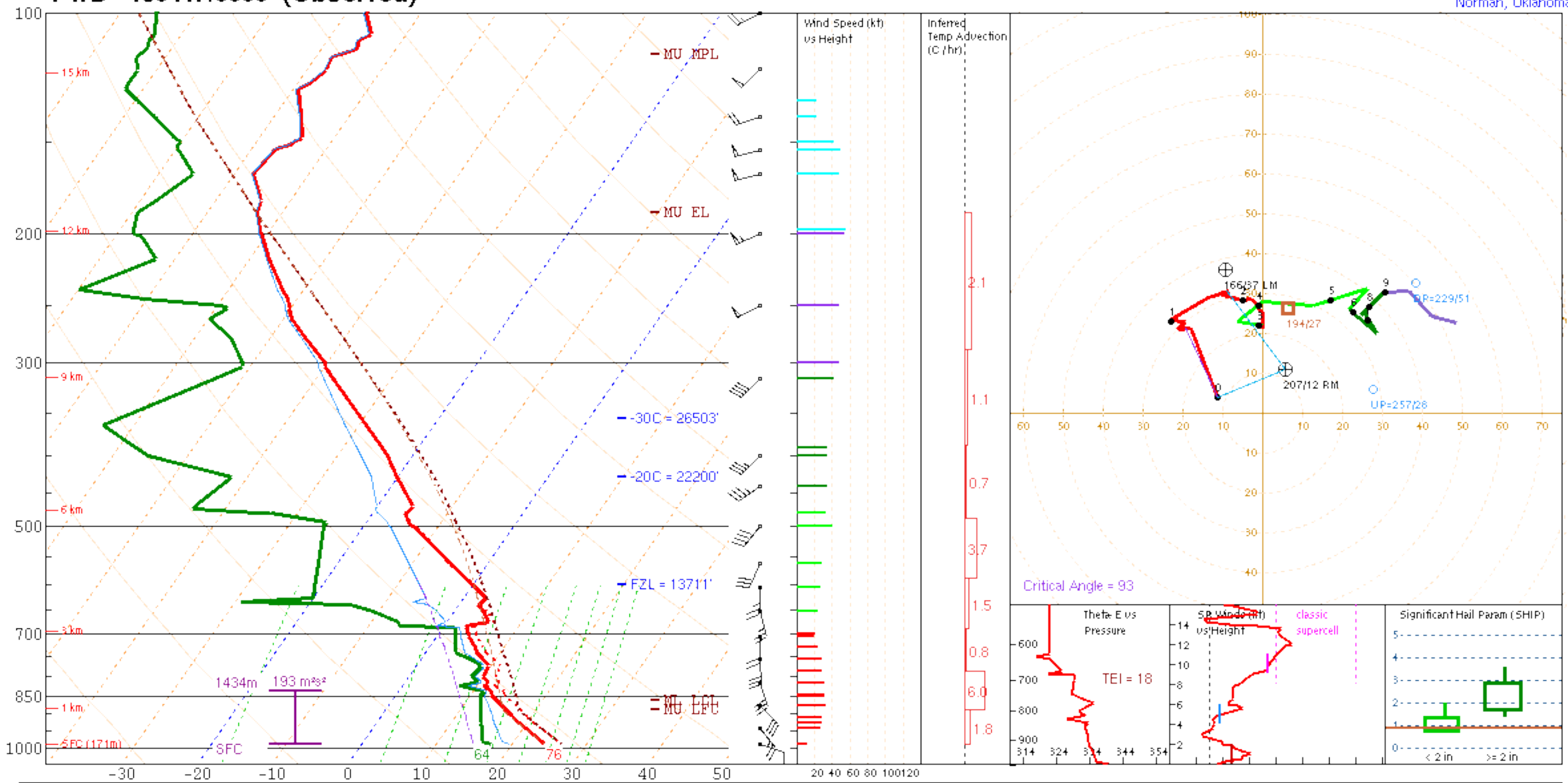
$$w = 55.5 \text{ m s}^{-1}$$

3. What is the maximum size hail stone (in diameter, either in inches or mm) that would exist, due to this vertical velocity. The tables for this are on the class website. (25 points)

According to the values given in this table: http://tornado.sfsu.edu/geosciences/classes/e260/HailGrowth/UpdraftSpeeds.png, the diameter of the maximum hail size would be greater than 4 ½" or 114 mm.

FWD 160417/0000 (Observed)

NOAA/NWS Storm Prediction Center
Norman, Oklahoma



PARCEL	CAPE	CINH	LCL	LI	LFC	EL
SURFACE	1542	-0	920m	-6	968m	40517'
MIXED LAYER	617	-48	1203m	-4	4427m	37576'
FCST SURFACE	1164	-5	1505m	-5	4096m	39426'
MU (987 mb)	1542	-0	920m	-6	968m	40517'

PW = 1.28 in | 3CAPE = 29 J/kg | WBZ = 10253' | WNDG = 0.0
K = 36 | DCAPE = 859 J/kg | FZL = 13711' | ESP = 0.2
MidRH = 72% | DownT = 59 F | ConvT = 83F | MMP = 0.52
LowRH = 78% | MeanW = 11.3 g/kg | MaxT = 81F | NCAPE = 0.14
SigSevere = 12718 m3/s3

Sfc-3km Agl Lapse Rate = 7.4 C/km
3-6km Agl Lapse Rate = 6.7 C/km
850-500mb Lapse Rate = 6.5 C/km
700-500mb Lapse Rate = 6.8 C/km

Supercell = 6.0
Left Supercell = 2.2
STP (eff layer) = 0.4
STP (fix layer) = 0.6
Sig Hail = 0.9

	SRH(m2/s2)	Shear(kt)	MnWind	SRW
SFC - 1 km	89	22	135/25	106/24
SFC - 3 km	213	21	154/26	124/21
Eff Inflow Layer	193	27	140/26	111/25
SFC - 6 km		40	168/24	140/17
SFC - 8 km		44	176/24	149/15
LCL - EL (Cloud Layer)		71	193/27	179/15
Eff Shear (EBWD)		41	169/24	141/16

BRN Shear = 28 m²/s²
4-6km SR Wind = 205/19 kt

.....Storm Motion Vectors.....
Bunkers Right = 207/12 kt
Bunkers Left = 166/37 kt

Corfidi Downshear = 229/51 kt
Corfidi Upshear = 257/28 kt

1km & 6km AGL Wind Barbs

*** BEST GUESS PRECIP TYPE ***
Rain.
Based on sfc temperature of 76.3 F.

SARS - Sounding Analogs

SUPERCELL	SGFNT HAIL
00031022.BHM NON	97061200.TOP 2.75
	90071700.FNT 1.75
	00051800.GSO 1.50
	03042400.SHU 1.00
	90042100.OUN 0.75
(24 loose matches)	(83 loose matches)
SARS: 33% TOR	SARS: 24% SIG

Effective-Layer STP (with CIN)

Prob EF2+ Torn with supercell
Sounding CLIMO = .15 sigtor

based on MLCAPE:	0.16
based on MLLCL:	0.15
based on ESRH:	0.08
based on EBWD:	0.12
based on STP_fixed:	0.11
based on STP_effective:	0.08

EF4+ EF3 EF2 EF1 EF0 NONTOR