EXAM NUMBER _____

NATS 101, Section 13, Fall 2010
Midterm Examination #2
October 22, 2010

Name: KEY **SID: _____**

Instructions:

- **Write your name and student ID on ALL pages of the exam.**
- In the multiple-choice/fill in the blank section, please fill-in only **ONE** answer. **Use the multiple choice scantron answer sheet. Turn this sheet in separately when you hand in your exam. You should also record multiple choice answers next to the question, as scantron sheets will not be returned.**
- In the short answer section, please make sure to read each question carefully and show your work where it is required. Should you need more room to answer your questions, you can use the other side, and indicate it with the answer.
- You **CANNOT** use a calculator.
- You are **NOT** allowed to use your book or notes on this exam.
- You are **NOT** allowed to talk about or look at anyone else's exam. If you commit such an offense, you will be awarded a **0** and the offense will be noted in accordance to **The Code of Academic Integrity**.
- Good luck!

Score:

Multiple Choice Section:	25 / 25 points
Short Answer Section:	15 / 15 points
Bonus Questions:	7 / 7 points
Total:	47 / 40 points

Helpful constants

Dry adiabatic lapse rate = 10 ºC per km (approximately)

Moist adiabatic lapse rate = 6 ºC per km (approximately)

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Midterm Examination #2
NATS 101, Section 13, Fall 2010
Introduction to Weather and Climate
Multiple Choice Section

Scoring: Each question is worth 1 point in this section.

1. Which of the following is not a form of precipitation?
   a) Rain
   b) Snow
   c) Fog
   d) Sleet
   e) Hail.

2. Which type of cloud would produce hail?
   a) Cirrus.
   b) Cirrocumulus.
   c) Cumulonimbus
   d) Nimbostratus.
   e) All of the above cloud types can produce hail.

3. Which of the following is **not** characteristic of an El Niño event?
   a) Eastern Pacific sea surface temperatures become colder than normal
   b) The strength of the trade winds in the Pacific decrease
   c) There is typically more winter rainfall in Arizona
   d) Rainfall decreases in Indonesia and Australia.
   e) None of the above

4. If lenticular clouds are observed downwind of a mountain range an airplane flying in this area would _____.
   a) Not experience turbulence because these are fair weather clouds.
   b) Experience turbulence because these clouds indicate rotor circulations
   c) Experience turbulence because these are thunderstorm clouds that can produce a microburst.
   d) Both (b) and (c).
   e) None of the above.

5. Which of the following cloud types produces widespread and steady light to moderate intensity precipitation?
   a) Cumulus castellanus
   b) Nimbostratus
   c) Cumulonimbus
   d) Cirrocumulus
   e) None of the above

6. With respect to lines of constant surface pressure, or isobars, surface winds will tend to blow _____ .
   a) Exactly perpendicular to the isobars towards low pressure
   b) Exactly perpendicular to the isobars towards high pressure
   c) Exactly parallel to the isobars
   d) Nearly parallel to the isobars, but curved slightly towards low pressure
   e) Nearly parallel to the isobars, but curved slightly towards high pressure

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7. A Chinook wind _____.
   a) Melts snow because it is warm
   b) Freezes crops because it is cold
   c) Forms because high altitude air radiates energy to space
   d) Is typically found upwind of mountain ranges
   e) None of the above

8. If the surface temperature is 18ºC and a parcel of air from the surface is lifted 1 km to the lifting condensation level, what will the final temperature of the parcel be?
   a) 12º C
   b) 24º C
   c) 8º C
   d) 28º C
   e) None of the above

9. In the upper-levels of the atmosphere, given a constant pressure gradient force, the wind will tend to _____ to the east of a trough of low pressure causing the air to _____ in this area.
   a) Speed up; sink
   b) Slow down; sink
   c) Speed up; rise
   d) Slow down; rise

10. Adiabatic means _____.
   a) Heat is exchanged with the surrounding environment
   b) There is turbulent mixing of air masses
   c) Density decreases with height.
   d) Air is conditionally unstable.
   e) None of the above

11. Cloud drops can grow rapidly into raindrops mainly because _____.
   a) The curvature of cloud drops enhances the condensation process.
   b) Cloud condensation nuclei allow cloud drops to form as soon as saturation is reached.
   c) Cloud drops of differing sizes collide and coalesce with each other
   d) All of the above
   e) None of the above

12. The atmosphere would be conditionally unstable if the environmental lapse rate, or rate of temperature decrease with height is _____ degrees Celsius per kilometer.
   a) 3
   b) 5
   c) 8
   d) 11
   e) Any of the above

13. Which type of fog forms over the coastal regions of the Pacific Ocean?
   a) Radiation fog
   b) Advection fog
   c) Upslope fog
   d) Evaporation fog
   e) None of the above.

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14. The atmosphere will become more unstable if the surface temperature _____ and the temperature aloft in the atmosphere _____.
    a) Decreases; decreases
    b) Decreases; increases
    c) Increases; decreases
    d) Increases; increases

15. Which cloud type would indicate the most unstable atmosphere?
    a) Cirrostratus
    b) Cumulonimbus
    c) Nimbostratus.
    d) Altostratus
    e) None of the above. All of the above cloud types occur in a stable atmosphere.

16. The final state of a wind where the pressure gradient force and the Coriolis force are balancing each other is called what?
    a) Cyclostrophic wind
    b) Hydrostatic wind
    c) Geostrophic wind
    d) Gradient wind
    e) None of the above

17. If you are flying in a jet airplane, the strongest turbulence would be experienced if you flew through which type of cloud?
    a) Cumulus castellanus
    b) Nimbostratus
    c) Cumulonimbus
    d) Stratocumulus
    e) Equally strong turbulence could be expected when flying through all these types of clouds.

18. What is the type of force balance that governs the wind in a tornado?
    a) Geostrophic
    b) Gradient
    c) Gradient with friction
    d) Cyclostrophic
    e) Hydrostatic

19. The Coriolis force is
    a) Strongest at the equator
    b) Important for smaller scale motion
    c) Caused by the rotation of the Earth
    d) All of the above.
    e) None of the above.

20. Aside of extreme heat, what is the most dangerous severe weather hazard in the state of Arizona?
    a) Hail
    b) Flash flooding
    c) Tornadoes
    d) Dust storms, or haboobs
    e) Dust devils

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21. Which of the following mechanisms lift air and promote cloud formation?
    a) Orographic lifting
    b) Frontal lifting
    c) Convergence
    d) Localized convective lifting due to buoyancy
    e) All of the above.

22. Which of these U.S. states has the greatest occurrence of strong tornadoes?
    a) Washington
    b) Arizona
    c) New York
    d) Kansas
    e) The occurrence of strong tornadoes is about the same in all of these states.

23. If the upper-level winds are relatively light, the wind on the side of a mountain will usually be _____ during the day and _____ at night.
    a) downslope; upslope
    b) downslope; downslope
    c) upslope; upslope
    d) upslope; downslope
    e) None of the above.

24. Where are most desert regions of the world found?
    a) At the equator
    b) In the tropics
    c) In the subtropics
    d) In the mid-latitudes
    e) Deserts are equally likely to be found in all of the above places

25. A layer of the atmosphere where temperature increases with height is:
    a) Stable
    b) Unstable
    c) Conditionally unstable
    d) None of the above

VERSION A

EXAM NUMBER _____

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Midterm Examination #2
NATS 101, Section 13, Fall 2010
Introduction to Weather and Climate
Short Answer Section

Scoring: Each question is worth points as indicated.

26. Why do monsoon thunderstorms in Arizona typically form over the mountains during the afternoon? Why do thunderstorm clouds always have flat bases and the most intense thunderstorms have flat anvil tops? (**5 points**)

Monsoon thunderstorms typically form over the mountains because: 1) the afternoon is the hottest part of the day and the heating of the ground surface causes the atmosphere to be more unstable; and 2) the mountains heat faster relative to the air surrounding them, so air is drawn up the mountain slopes during the afternoon and rises above the mountain peaks. In Arizona during the monsoon, convective clouds start to form as soon as the mountains begin to heat during the morning and may grow to become thunderstorms later in the afternoon.

Thunderstorm clouds always have flat bases because this defines the lifting condensation level, or the point at which a rising parcel of air from the surface has adiabatically expanded and cooled to its dew point temperature. The relative humidity is 100% at this point and water will start condensing to form a cloud since there are always cloud condensation nuclei available in the atmosphere.

The most developed thunderstorm (cumulonimbus) clouds have flat anvil tops for two reasons: 1) the flat top defines the point where air rising in the cumulonimbus cloud has reached the top of the troposphere and the beginning of the stratosphere. Since the temperature begins to increase with height beyond this point, the atmosphere is stable and the cloud top will tend to flatten and spread out; and 2) high winds are typically found at this altitude and these tend to spread out the cloud tops. Either or both of these answers were acceptable.

Scoring:

2 points for explanation of thunderstorm formation
2 points for explanation about thunderstorm flat cloud bases
1 point for explanation about thunderstorm flat cloud tops

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27. Describe how hail forms. How is this process similar or different from the formation of other forms of frozen precipitation, like freezing rain, sleet, and snow? **(5 points**)

Hail forms almost always in a cumulonimbus cloud when an ice crystal embryo near the top or middle of the cloud begins to accrete supercooled water droplets. As these supercooled water droplets contact the hailstone embryo, they freeze on contact, causing the hailstone to grow into roughly a spherical shape. This process continues and the hailstone may continue to grow so long as the hailstone is suspended within the cumulonimbus cloud by updrafts. The larger the hailstone, therefore, the more powerful the updrafts in the thunderstorm and typically more severe it is. When the weight of the hailstone can no longer be supported by the updrafts within the cumulonimbus cloud, it falls out of the cloud to the surface. Because hail almost always occurs in very developed thunderstorms, it mostly occurs during the warm season when thunderstorms are more likely to occur.

Hail is similar to the other frozen forms of precipitation in the respect that it requires temperatures below freezing in the atmosphere to form and grows by accretion of smaller water or ice particles. The other types of precipitation, by contrast, tend to form in more stable clouds (nimbostratus), occur much more during the cool season, and depend more on the temperature profile of the lower atmosphere below cloud base. Snow requires temperatures to be below freezing in the lower atmosphere, whereas freezing rain and sleet require an intervening layer of warm air above freezing to melt precipitating particles and then these particles refreeze before hitting the ground.

<u>Scoring:</u>

3 points for physical mechanisms of hail formation
2 points for comparing and contrasting with other frozen precipitation forms

VERSION A

28. Explain the difference between thermal turbulence and mechanical turbulence. Give at least one of example of where each would be encountered in the atmosphere. (**5 points**)

Thermal turbulence: Turbulence associated with differential heating of the land surface, causing the warm air to rise and the cold air to sink. This process was demonstrated in class with the convection in a boiling pot experiment, where the convection was visible in the form of rising warm plumes in the fluid.

Example: In Arizona, it would typically occur during the afternoon in summer as the mountains heat and cause the development of convective clouds, if it is monsoon season.

Mechanical turbulence: Turbulence associated with wind rapidly changing speed or direction. Aloft this is can be caused by fast moving air associated with the jet stream. Nearer the surface, it is caused by airflow being obstructed by a physical obstacle, such as a building, tree, or mountain. Downwind of the obstacle, turbulent eddies tend to form.

Example: Mountain wave clouds that occur downwind of the Rocky Mountains in winter are an indication of lee-wave rotor circulations.

Scoring

2 points for physical description of thermal turbulence
2 points for physical description of mechanical turbulence
1 point for examples of where these occur in the atmosphere

VERSION A

BONUS QUESTION: Describe the cloud in the bottle experiment, as shown in class lecture. Physically explain the reason(s) for the cloud formation in this experiment. (**5 Points Extra Credit**)

The cloud in the bottle experiment consisted of two parts. In the first part, water was filled in a flask and swished around so as to moisten the sides of the flask. The flask was sealed with a rubber stopper and the pressure was increased with the aid of a bicycle pump. The air pressure was released from the flask by removing the rubber stopper. Nothing happens in the flask, though. In the second part, the experiment is repeated exactly the same way, except this time a smoking, blown out match is introduced before the flask is sealed and air is pumped into the flask. When the pressure is released the second time, the inside of the flask fogs up due to the formation of a cloud within.

There are two physical reasons for the cloud formation in the second part of the experiment:

1) *When the rubber stopper is removed from the top of the flask, the pressure decreases within the flask and the air rapidly expands adiabatically. In other words, the expansion of the air causes its temperature to cool. This is similar to a rising parcel of air in the atmosphere. This happens in both parts of the experiment.*
2) *The smoke particles from the match introduce cloud condensation nuclei, or provide a surface for the water to more readily condense upon, once the temperature of the air within the flask has cooled to its dew point temperature. When this happens, and the relative humidity equals 100%, a cloud immediately forms.*

Scoring:

1 point for experiment description
2 points for explanation of temperature decrease
2 points for explanation of cloud condensation nuclei

BONUS QUESTION #2: Name the two countries to which Professor Castro recently traveled to give talks on the subject of climate change. (**2 Points Extra Credit**)

Jamaica
Dominican Republic

VERSION A