

**EXAM NUMBER** \_\_\_\_\_

**NATS 101, Section 13, Fall 2010  
Midterm Examination #1  
September 20, 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:**

<b>Multiple Choice Section:</b>	25 / 25 points
<b>Short Answer Section:</b>	15 / 15 points
<b>Bonus Questions:</b>	5 / 5 points
<b>Total:</b>	45 / 40 points

**Helpful constants:**

Constant in Stefan-Boltzmann law =  $6.0 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$  (approximately)

Constant in Wien's displacement law =  $3000 \text{ } \mu\text{m K}$  (approximately)

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**Midterm Examination #1**  
**NATS 101, Section 13, Fall 2010**  
**Introduction to Weather and Climate**  
**Multiple Choice Section**

**Scoring:** Each question is worth 1 point in this section. Underlined indicates correct answer.

1. If the temperature of an object is doubled, by what factor does its total radiant energy per unit area increase?
  - a) 2
  - b) 8
  - c) 16
  - d) 32
  - e) None of the above.
  
2. On June 21<sup>st</sup>, the sun is directly over head at solar noon at which of the following special locations with respect to latitude on Earth?
  - a) The equator
  - b) The Tropic of Capricorn
  - c) The Tropic of Cancer
  - d) The Arctic Circle
  - e) The Antarctic Circle
  
3. Which of the following locations has the highest relative humidity?
  - a) Temperature: 8°F, Dew point: 7°F
  - b) Temperature: 25°F, Dew point: 20°F
  - c) Temperature: 40°F, Dew point: 33°F
  - d) Temperature: 70°F, Dew point: 60°F
  - e) The relative humidity at all of the above stations is the same.
  
4. Which of the following wavelengths corresponds to infrared radiation?
  - a)  $10^{-3}$  m (or 1000  $\mu\text{m}$ )
  - b)  $10^{-5}$  m (or 10  $\mu\text{m}$ )
  - c)  $10^{-7}$  m (or 0.1  $\mu\text{m}$ )
  - d)  $10^{-9}$  m (or 0.01  $\mu\text{m}$ )
  - e) None of the above
  
5. Which of the following U.S. cities would you expect to have the largest annual variation in monthly average temperature?
  - a) Miami, Florida
  - b) Seattle, Washington
  - c) Chicago, Illinois
  - d) Atlanta, Georgia
  - e) None of the above. The annual variation in temperature at all of these places is the same.
  
6. Which of the following modes of heat transfer refers to the mass movement of a fluid or gas?
  - a) Conduction
  - b) Convection
  - c) Radiation
  - d) Latent Heat
  - e) None of the above

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7. Which of the following substances has the highest heat capacity?
- Liquid water
  - Air
  - Common metals, like iron
  - Wood
  - Soil
8. At Stonehenge Aotearoa, the replica of Stonehenge located in New Zealand, on December 21 the sun will rise in the \_\_\_\_\_ and set in the \_\_\_\_\_. *Hint: New Zealand is located at approximately 40°S latitude in the South Pacific Ocean.*
- East, West
  - Southeast, Northwest
  - Southeast, Southwest
  - Northeast, Northwest
  - Northeast, Southwest
9. Which of the following factors is related to the occurrence of seasons on Earth?
- The eccentricity of Earth's orbit.
  - The rate of rotation of the Earth about its axis.
  - The obliquity of the Earth's axis with respect to its orbital plane.
  - All of the above.
  - None of the above is related to the occurrence of seasons.
10. Atmospheric pressure is measured using which of the following devices?
- Thermometer
  - Barometer
  - Anemometer
  - Hygrometer
  - None of the above
11. What is the most abundant gas in the atmosphere?
- Oxygen
  - Nitrogen
  - Carbon dioxide
  - Argon
  - None of the above.
12. On a location on the equator, like Ecuador as discussed in class, the longest day of the year would occur on approximately which date?
- March 21
  - June 21
  - September 22
  - December 21
  - None of the above. The length of the day is the same all year round.
13. The SI units of a Newton are:
- $\text{kg m s}^{-1}$ .
  - $\text{kg m}^2 \text{s}^{-1}$
  - $\text{kg m s}^{-2}$
  - $\text{kg m}^2 \text{s}^2$
  - $\text{kg m}^2 \text{s}^{-1}$ .

14. The wavelength of maximum radiation emission of an object is:
- Directly proportional to its temperature.
  - Inversely proportional to its temperature.
  - Not related to its temperature.
15. Which of the following substances has the highest heat conductivity?
- Liquid water
  - Air
  - Common metals, like iron
  - Wood
  - Soil
16. Which of the following is not a way to increase evaporation from a pool of standing water?
- Increase the air temperature.
  - Increase the wind speed.
  - Increase the relative humidity of the air.
  - Doing any of the above can increase the rate of evaporation.
17. Identify the correct conversion equation from degrees Fahrenheit to degrees Celsius:
- $^{\circ}\text{C} = (5/9) \times (^{\circ}\text{F} - 32)$
  - $^{\circ}\text{C} = (9/5) \times (^{\circ}\text{F} - 32)$
  - $^{\circ}\text{C} = (5/9) \times (^{\circ}\text{F} + 32)$
  - $^{\circ}\text{C} = (9/5) \times (^{\circ}\text{F} + 32)$
  - None of the above
18. Which of the following locations has the most amount of water vapor in the air?
- Temperature: 8°F, Dew point: 7°F
  - Temperature: 25°F, Dew point: 20°F
  - Temperature: 40°F, Dew point: 33°F
  - Temperature: 70°F, Dew point: 60°F
  - The amount of water vapor in the air is the same at all of the above stations.
19. Under which of the following conditions would the minimum temperature mostly likely be the lowest?
- A clear and calm night
  - A cloudy and calm night
  - A clear and windy night
  - A cloudy and windy night
  - The minimum temperature would probably be about the same in all of the above conditions.
20. The SI units of a Pascal, the fundamental unit to measure air pressure, are:
- $\text{kg m s}^{-1}$
  - $\text{kg m s}^{-2}$
  - $\text{kg m}^2 \text{s}^{-2}$
  - $\text{kg m}^2 \text{s}^{-3}$
  - None of the above
21. The average temperature of Mars is about 200 K and the average temperature of Earth is about 300 K. What is the approximate percentage of radiant energy per unit area emitted by Mars as compared to Earth?
- 10%.
  - 20%.
  - 30%.
  - 45%.
  - 66%.

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22. The Earth is closest to the sun in which northern hemisphere season?
- a) Winter: December to February
  - b) Spring: March to May
  - c) Summer: June to August
  - d) Fall: September to November
  - e) None of the above. The Earth is the same distance from the sun at all times during the year.
23. The temperature increases with height in which of the following layers of the atmosphere?
- a) Troposphere
  - b) Mesosphere
  - c) Stratosphere
  - d) All of the above
  - e) None of the above
24. What percentage of Earth's atmosphere is composed of carbon dioxide?
- a) About 80%
  - b) About 60%
  - c) About 40%.
  - d) About 20%.
  - e) None of the above
25. The sky is blue because gases in the atmosphere \_\_\_\_\_.
- a) Emit their most intense radiation in the blue part of the visible spectrum
  - b) Reflect blue light from the ocean
  - c) Are more transparent to blue light than the other colors of visible light
  - d) Scatter blue light more than the other colors of visible light
  - e) All of the above

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**Midterm Examination #1  
NATS 101, Section 13, Fall 2010  
Introduction to Weather and Climate  
Short Answer Section**

**Scoring:** Each question is worth points as indicated.

26. The sun is an object with a surface temperature of approximately 6000 K. What is the wavelength of most intense radiation emission from the sun ( $\lambda_{\max}$ )? What type of radiation is this, as classified by the electromagnetic spectrum? (**5 points**)

*Wien's displacement law states that the wavelength of maximum radiation emission from an object is inversely proportional to its temperature.*

$$\lambda_{\max} = \frac{\text{constant}}{T_{\text{object}}} = \frac{3000 \mu\text{mK}}{6000\text{K}} = 0.5 \mu\text{m}$$

*This wavelength falls in the visible light portion of the electromagnetic spectrum*

Scoring:

*2 points for setting up calculation*

*2 points for performing calculation correctly*

*1 point for type of radiation*

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27. Explain how the earth's atmospheric greenhouse effect works. What atmospheric gases are primarily responsible for the greenhouse effect and why? What would happen to the surface temperature on Earth without the greenhouse effect? Feel free to use illustrations in your answer. **(5 points)**

*Earth's atmosphere is analogous to a greenhouse in the following ways:*

- 1) Solar (shortwave) part of the electromagnetic spectrum: The windows of the greenhouse and the gases in the atmosphere are fairly transparent to solar radiation, so most of the sunlight passes through and this energy reaches the surface and heats it.*
- 2) Infrared or terrestrial (longwave) part of the electromagnetic spectrum: The windows of the greenhouse and gases in the atmosphere are fairly opaque to terrestrial radiation, so the terrestrial radiation emitted by the earth is mostly absorbed. In the atmosphere, absorption of infrared radiation is maximized at selective wavelengths because of the molecular structure of greenhouse gases. The greenhouse gases then re-emit longwave radiation downward to the surface, providing an additional source of energy to the surface to increase the temperature.*

*The primary gases responsible for the greenhouse effect are carbon dioxide and water vapor, but credit was given if others were mentioned.*

*Without the greenhouse effect, all the longwave radiation emitted by the Earth's surface would escape to space, and the surface temperature would be well below freezing (or Earth would basically be an ice ball).*

*Scoring:*

*3 points for describing the physics of the greenhouse effect*

*1 point for greenhouse gases*

*1 point for describing effect on Earth's surface temperature*

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28. Two common measures to report atmospheric moisture, for example in a TV weather report, are relative humidity and dew point temperature. Provide physical definitions of these two measurements and explain the difference between them, if any. **(5 points)**

*Relative humidity: The ratio of actual amount of water vapor in the atmosphere (vapor pressure) divided by the maximum amount of water vapor that the atmosphere can potentially hold at the given air temperature (saturation vapor pressure). Typically expressed as a percentage.*

*Dew point temperature: Temperature at which air must be cooled in order for condensation to occur.*

*Difference: Relative humidity is dependent on both the actual amount of water vapor and the atmosphere and the air temperature. Dew point is an absolute measure of atmospheric moisture and does not depend on the air temperature.*

Scoring:

*2 points for definition of relative humidity*

*2 points for definition of dew point temperature*

*1 point for explaining difference between the two*



**BONUS QUESTION:** In Arizona, in many older houses it is common to use evaporative cooling, or a swamp cooler, in lieu of any air conditioning even though it is one of the hottest places in the country. Why do swamp coolers work well in a dry, hot climate like Arizona's, but not in a moist, humid climate like the Southeast U.S? (**5 Points Extra Credit**)

*Swamp coolers work on the principle of evaporative cooling. They work well in Arizona because the relative humidity of the air is generally very low most of the time. Therefore the air is holding much less water vapor than it can potentially hold, and the evaporation rate is large. The phase transition of water from liquid to gas phase in the evaporation process chills the air.*

*However, in a moist humid climate, if the relative humidity is very high (at or near 100%) then the air is already nearly saturated and cannot hold much more water vapor. Therefore little, if any evaporation and associated evaporative cooling would occur in this situation.*

**Scoring:**

*2-3 points: Explanation of why swamp coolers work in Arizona*

*2-3 points: Explanation of why swamp coolers don't work in a humid climate*

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