NAME:______________________________ LAB SECTION

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EAS 1600 - INTRODUCTION TO ENVIRONMENTAL SCIENCES

Fall, 2015

Exam 1 – 9/14/15

< **Relevant formulas, etc are included at the end of the exam**
< **Place your name on each page**
< **This is a closed-book exam; all are expected to comply with Georgia Tech Honor Code**

I am aware and in compliance with the Georgia Tech Honor Code. I also agree to abide by the grading policies of this class.

Signature: ____

Version A

Answer the following multiple choice questions (1-10) by circling the best answer. (5 pts each)

1. Consider a Daisyworld type planet with black daisies and a temperature that is less than the optimal temperature for daisy growth. If the temperature suddenly increases________________.
Fill in the blank with the best answer

a) nothing happens to the daisy coverage
b) the daisy coverage increases and the planet warms until all the daisies are dead.
c) the daisy coverage increases and the planet cools back to its original temperature.
d) the daisy coverage increases and the planets warms a until the optimal temperature for daisy growth is reached and the amount of daisies is stable.

2. Roughly how many hours of daylight will Summit, Greenland (latitude = 72^o N) receive on January 1?
a) 8
b) 0
c) 12
d) 24

3. All of the items listed below are at temperature of 255 K. Which of the items emits the largest flux of radiation.

a) The Earth
b) A satellite orbiting Venus
c) A comet shaded from the Sun by the Earth
d) They all emit the same flux

4. Estimate the ratio of the solar radiation at noon impacting Moscow (latitude = 56^o N) during its summer to that impacting McMurdo Station (72^o S) during its summer.

a) 0.79
b) 0.3
c) 4.6
d) 1.3

5. Mars has an Arctic Circle located at a latitude of 65^o N. The tropics on Mars are located at _____ and the tilt of the rotational axis is ___________.

a) 15^o N and 15^o S, 75^o
b) 25^o N and 25^o S, 25^o.
c) 23.5^o N and 23.5^o S, 23.5^o.
d) 25^o N and 25^o S, 65^o

6. South Korea (population = 50 million) fears that its native population may be extinct by the year 2750. What is the best estimate of the population growth rate in South Korea?

a) 0.012 % $year^{-1}$
b) -2.4% $year^{-1}$
c) -0.01% $year^{-1}$
d) -0.012 $year^{-1}$

7. A star emits light with a primary wavelength of 850 nm. The flux emitted by the star is?

a) 1370 W/m^2
b) 7,661 W/m^2
c) 7,661 kW/m^2
d) 7.661 x 10^{-6} W/m^2

8. Visible light from the Sun is __________ in the Earth's atmosphere and is __________ and heats the Earth's surface.
Fill in the blanks with the best answer below

a) reflected, transmitted
b) reflected, reflected
c) transmitted, transmitted
d) transmitted, absorbed

9. A star emits light that appears blue to us. The star is _______ than the Earth.

a) hotter than
b) colder than
c) the same temperature as

10. Light in which region of the electromagnetic spectrum is more energetic?

a) Visible
b) Infrared
c) Ultraviolet

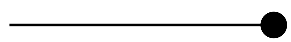
11. (10 pts) Draw a systems diagram for a satellite that orbits the Sun at the same distance as the Earth. Use the following components: 1) Temperature of the cube 2) Albedo of the cube 3) IR flux from the cube and 4) Solar flux.
Be sure and label all couplings and indicate any feedback loops (positive or negative) and state if they are stable or unstable.

Notation to use for Systems Diagram:

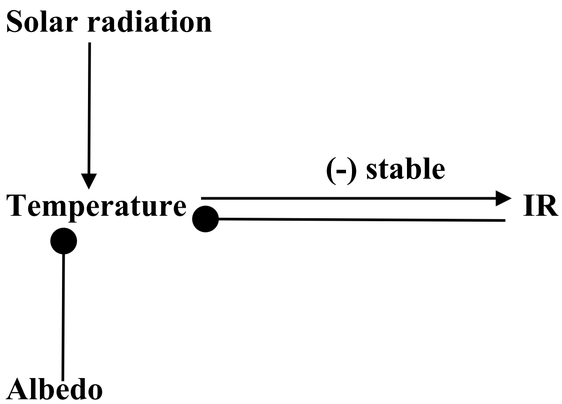
positive coupling:

positive feedback: **(+)**

negative coupling:



negative feedback: **(-)**



12. (10 pts) Assuming that Venus is 20% closer to the Sun than the Earth and that it has an albedo of 0.45. Estimate the effective temperature of Venus.

$$S = S_0(\frac{r_0}{r})^2 = 1370\times(\frac{1}{0.8})^2 = 2140.6\ W/m^2$$

$$\mathrm{T_{eff}} = \left(\frac{\mathrm{S}(1-\mathrm{A})}{4\sigma}\right)^{1/4} = 268.4\ K$$

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13. Consider a thin square metal plate orbiting the Sun. The plate has sides of length of 10 m and an albedo of 0.2. The temperature of the plate is 355 K. The plate is oriented so that the radiation from the Sun strikes the plate at an angle of 75° above the surface of the plate. The plate orbits the Sun at the same distance as the Earth.

a) What is the flux emitted by the plate? (5 pts)

$$S_{emit} = \sigma T^4 = 5.67\times10^{-8}\times355^4\ W/m^2 = 900.5\ W/m^2$$

b) What is the power emitted by the plate? (5 pts)

P=S*Area=900.5 W/m^2 * 100m * 100m * 2 = 180 kW

c) What is the total energy absorbed on the surface of the plate in 3 minutes (10 pts)

$$S = S_0 \cos(q) = 1370\times \cos(15°)\ \mathrm{W}/m^2 = 1323\ \mathrm{W}/m^2$$

E=(1-A)*Area*S*t=(1-0.2)*100*100*1323*3*60=1.9*10^7 J

d) Is the plate heating up or cooling down? Why? (5 pts)

Cooling, energy out (3.2*10^7 J in 3 min) >energy in (1.9*10^7 J in 3 min)

14. If you wanted to change the effective temperature of the Earth to 215 K what albedo would be needed?

(10 points)

$$T_{eff} = \left(\frac{S(1-A)}{4\sigma}\right)^{1/4}$$

$$A = 1 - \frac{4\sigma T^4}{S} = 0.65$$

Formulas, facts, and constants you may find useful:

1. The latitude of a point is earth is defined as the angle defined by that point, the center of the Earth, and the Equator. For Example, the Equator is 0^o, and the South Pole is 90^o S.

2. $\mathbf{P(t)=P(t_o)e^{rt}}$
population at time t related to original population at t_o and the growth rate constant - r

3. speed of light = c = $\lambda\,\upsilon$ = 3×10^8 m/s
where λ = wavelength and υ = frequency

4. energy of a photon = E = $h\upsilon$ = hc/λ
where h = Planck's constant = 6.63×10^{-34} Js

5. **S** = radiant flux at a distance r from a point source = $\mathbf{S_o\,[r_o/r]^2}$

6. Surface area of a sphere with radius r; $\mathbf{A = 4\pi r^2}$

7. λ_{max} = the wavelength (in µm) at which a blackbody at effective temperature T_{eff} (in K) has its maximum radiant flux

$$\lambda_{max} = \frac{2898\mu mK}{Teff}$$

8. S = radiant flux leaving the surface of a blackbody at temperature T (in K)

$$\mathbf{S = \sigma T_{eff}^4}$$

where σ = Stefan-Boltzman constant = 5.67×10^{-8} W/(m^2 K^4)

9. T_{eff} = planet's effective temperature

$$\boldsymbol{T_{eff} = \left(\frac{S^*(1-A)}{4\sigma}\right)^{1/4}}$$

where (S^*) is the radiant flux impinging on the planet from its "sun" and A is albedo. For the Earth/Sun system S=1370 W/m^2

10. $\boldsymbol{S = S_o cos(q)}$
where S is the flux on a surface that receives radiation at an incident angle of q.
S_o is the radiation above the surface measured perpendicular to its propagation.