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EAS 1600 - INTRODUCTION TO ENVIRONMENTAL SCIENCES

Fall, 2014

Exam 1 – 9/12/14

- **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: _____

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

1. Consider a parking lot in Sydney, Australia (34 ^{o}S) on December 22 at local noon. Estimate the incident angle of solar radiation (i.e. q) impacting the parking lot.

a) 56^{o}
b) 10.5^{o}
c) 34^{o}
d) 57.5^{o}

2. Roughly how many hours of daylight will Moscow (latitude = 56^{o} N) receive today?

a) 8
b) 0
c) 13
d) 24

3. As the albedo of a planet increases, the temperature _____ and _____ light is absorbed by the planet. Fill in the blanks with the best answer.

a) increases, more
b) increases, less
c) decreases, more
d) decreases, less

4. Estimate the ratio of the solar radiation impacting Moscow (latitude = 56^{o} N) in summer to that in winter.

a) 4.6
b) 0.25
c) 1.8
d) 2.7

5. If the tilt of the Earth's rotational axis were tilted at 15^{o} (it is currently tilted at 23.5^{o}). Where would the Arctic Circle be located?
a) 30^{o} N.
b) 15^{o} N.
c) 75^{o} S.
d) 75^{o} N.

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) -2.5% year^{-1}
c) -0.01% year^{-1}
d) -0.012 year^{-1}

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7. Which of the following environmental changes and perturbations tends to raise the temperature of the Earth? Circle all that apply.

a) volcanic explosions
b) decreasing the length of the day
c) the temperature of the Sun increasing
d) an in increase in the extent of ice sheets

8. Visible light is _____ at the surface of the Earth and heats the Earth up so that it emits _____ .
Fill in the blanks with the best answer below

a) reflected, infrared radiation
b) absorbed, infrared radiation
c) absorbed, visible radiation
d) reflected, no radiation as it is all reflected

9. A star emits light with a primary wavelength of 320 nm. This star is _____ than our Sun.

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

10. A nail is heated to a temperature of 1000 K. What is the color of the nail?

a) blue
b) white
c) red
d) yellow

11. (15 pts) South Africa had a population of 45 million in 2000 which increased to 50 million in 2010. Estimate the growth rate as a percentage in this time period. Estimate how long it will take for South Africa's population to double. Estimate in which year the population will be 78 million?

i) $Pop(t) = Pop(t_0)e^{rt}$, $50000000 = 45000000e^{10r}$, r = 0.0105= 1.05%

ii) The time for Tanzania's population to double is:
$2 = e^{0.0105t}$, t=66 yr,
iii) $78000000 = 45000000e^{0.0105t}$, t = 52.4 yr
So in 2000+52.4 ≈ 2052, the population will be 78 million.

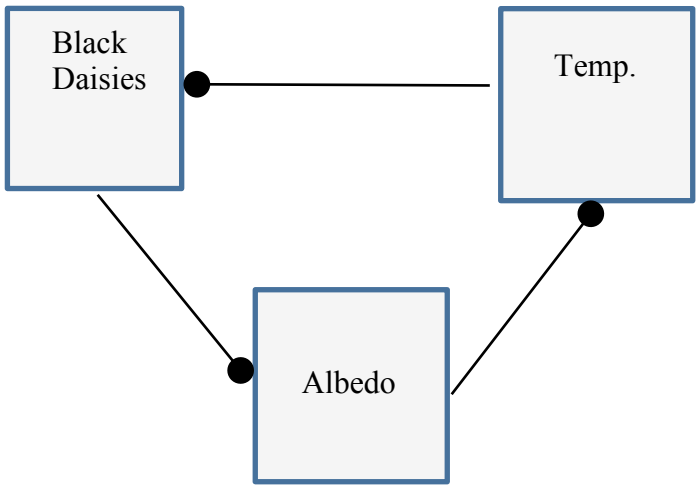
12. (10 pts) Draw a systems diagram for a Daisyworld that has **black daisies** that includes the following components: 1) Temperature 2) Albedo 3) Daisy Coverage for the case when the temperature is greater than the optimal temperature for daisy growth.

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: **(-)**



The feedback loop is negative, which means the system is stable.

13. How much energy is emitted by a 1 m square of blacktop that is at a temperature of 45 ^{o}C in one minute.

(5 points)

$$S = \sigma T^4 = 5.67\times10^{-8}\times(273+45)^4\, W/m^2 = 579.8\ W/m^2$$

$$E_{out} = SL^2t = \sigma T^4 L^2 t = 579.8\times1\times1\times60\, J = 34789\, J$$

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14. What is the maximum energy that could be absorbed by a 1 m square of blacktop in one minute assuming that he square is located in Atlanta (34^o N).

(10 points)

Assume on summer solstice day, and the albedo is 0.

$$E_{abs} = SL^2t = S_0\cos(q)L^2t = 1370\times\cos(34-23.5°)\times1\times1\times60\,J = 80824\,J$$

15. Assuming that Mars is 58% further away from the Sun than the Earth and that it has an albedo of 0.15. Estimate the average temperature of Mars.

(10 points)

$$S_{Mars} = S_E(\frac{r_E}{r})^2 = 1370\times(\frac{1}{1.58})^2 = 548.8\,W/m^2$$

Energy balance, In= Out

$$S_{Mars}(1-A)\times\pi r^2 = \sigma T^4 4\pi r^2$$

$$T^4 = \frac{S_{Mars}(1-A)}{4\sigma}$$

Therefore T = 213 K

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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 = $c = \lambda \upsilon = 3 \times 10^8$ m/s
where λ = wavelength and υ = frequency

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

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

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

$$\lambda_{max} = \frac{2898 \mu m K}{Teff}$$

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