Spring 2006

MAT 102
Survey of Contemporary Mathematical Topics

Final Exam

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Please print the requested information in the spaces provided:

Name:

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include to receive the final grade via email ONLY *if you are not getting email updates*

- *Any violation of academic integrity on this exam will result in a failing grade for the whole course.*

- *Notes and books are permitted, but cannot be shared.*

- *Graphing calculators, smartwatches, computers, cell phones and any other communication-capable devices are prohibited. Their mere presence in the open — even without use — is a violation of academic integrity.*

- *You will not receive full credit if there is no work shown, even if you have the right answer. Please don't attach additional pieces of paper: if you run out of space, please ask for another blank final.*

Problem 1. Compute the Euler characteristic of a curve that has the shape of the character 8.

Space for your solution:

Problem 2. Assume that a certain year starts on Monday and is not a leap year (has 365 days). What day of the week will be the first day of the following year?

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Problem 3. Suppose that a certain family has two children.

(1). If the first born child is a girl, what is the probability that the family has two girls?

(2). If instead at least one of these two children is a girl, what is the probability that the family has two girls?

Problem 4. This problem will introduce you to the *Rhesus Factor*.

Phenotype. An individual either has, or does not have, the *Rhesus factor D antigen* [1] on the surface of their erythrocytes. These two phenotypes are usually indicated by Rh+ (does have the the Rh(D) antigen) or Rh- (does not have the Rh(D) antigen) suffix appended to the ABO blood type.

Distribution. For example, the most typical blood type in the United States is O (Rh+) with 39% of the population having it; the least typical is AB (Rh-) shared only by 1% of Americans. In the African American population, 7% have the Rh- phenotype. Among the Americans of European descent, 16% have the Rh- phenotype.

Genetics. Rhesus factor is controlled by one gene [2], called Rh(D), located on chromosome one. The Rh- phenotype is recessive; the Rh+ phenotype is dominant.

Clinical Significance. An Rh- individual can get *immunized* against the Rh(D) antigen. Immunization can generally occur only through blood transfusion or — for women only — through placental exposure when giving birth. Immunized individuals produce anti-D antibodies. A woman who is

- Rh-

- immunized against the Rh(D) antigen, and

- pregnant with an Rh+ fetus (which may happen only if the father is Rh+),

will pass her anti-D antibodies to her fetus through placenta. Those antibodies will agglutinate the erythrocytes of the fetus, resulting in a severe anaemia or even death. This condition is called *Rh D Hemolytic* [3] *disease of the newborn* [4].

(1). Suppose a pregnant woman had no prior pregnancies or blood transfusions. Determine the probability of her current pregnancy being complicated by the Hemolytic disease of the newborn.

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[1] or *Rh(D) antigen* for short
[2] this is somewhat of an oversimplification
[3] literally: destroying blood cells
[4] also called the *Rhesus disease*

(2). How many alleles of the Rh(D) gene does one cell of each of the following types have?

- erythrocyte (red blood cell in the blood);

- neuron;

- sperm cell;

- ova cell.

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(3). Suppose a pregnant Rh- woman has two children: one Rh+, and another one is Rh- [5]. Her children, as well as her pregnancy, are from the same partner. What is the probability that the current pregnancy will be complicated by the Hemolytic disease of the newborn?

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[5]and has neither prior terminated pregnancies, nor deceased children

(4). Determine the frequency of the Rh- and Rh+ alleles in African American population, assuming that this population is in the state of Hardy-Weinberg equilibrium in regards to Rh(D) alleles. Round the answer to the nearest whole percent.

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(5). Assuming that African American population is in the state of Hardy-Weinberg equilibrium in regards to Rh(D) alleles, determine the probabilities that an African American person is 1) Rh+ and Rh(D) heterozygous and 2) Rh+ and Rh(D) homozygous. Round the answer to the nearest whole percent.

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(6). Using the results from the sub-problem (5), determine the probabilities that an Rh+ African American person is 1) Rh(D) heterozygous and 2) Rh(D) homozygous. Round the answer to the nearest whole percent.

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(7). Suppose a European American woman has her second pregnancy from the father of her first child, and had no prior pregnancies [6] or blood transfusions. What is the probability of the current pregnancy being complicated by the Hemolytic disease of the newborn? Round the answer to the nearest whole percent. Assume that the father is Rh+ homozygous.

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(8). Same as the previous sub-problem, but assume that the father is Rh(D) heterozygous.

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[6]meaning pregnancies from other partners

(9). Suppose a European American woman has her second pregnancy from the African American father of her first child, and had no prior pregnancies [7] or blood transfusions. What is the probability of the current pregnancy being complicated by the Hemolytic disease of the newborn? Use results from sub-problems (5), as needed. Round the answer to the nearest whole percent.

Space for your solution:

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[7]meaning pregnancies from other partners

(10). Using the Hardy-Weinberg principle, explain the difference in Rh(D) allele frequencies in African American and in European American populations.

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(11). Suppose a European American woman has her third pregnancy from the African American father of her first two children, and had no prior pregnancies or blood transfusions. Both of her children are healthy, i.e. did not suffer from the Hemolytic disease of the newborn. What is the probability of the current pregnancy being complicated by the Hemolytic disease of the newborn? Use results from all previous sub-problems, as needed. Round the answer to the nearest whole percent.

Space for your solution: