136.102 Math in Art
Midterm Exam
February 24, 2005

Name: ___________________________ Student Number _____________

Important: “Construct” means “construct using an unmarked ruler and a compass”. The phrase “unmarked ruler” stands for any ruler that may be used only as a straight edge to draw straight line segments. When you use a compass, show the (intermediate) circular arcs you draw in your constructions (do not erase them). Use words to describe BRIEFLY what you have done.

1. Subdivide the given line-segment into three equal parts (using an unmarked ruler and a compass). Do not forget to briefly describe your steps.

2. (a)[6] Construct a golden rectangle to the right of the line segment given below (the shorter side of the rectangle). Do not forget to briefly describe your steps.
3. (a) What are Fibonacci numbers? (Write down the definition.)

(b) The 22nd Fibonacci number $f_{22}$ is 17711. The 20th Fibonacci number $f_{20}$ is 6765. Find the 21st Fibonacci number $f_{21}.$

4. The lower image of an apple is obtained by rotating the other image of the apple around a center O and by an angle $\theta$. Construct the center O and identify the angle of rotation $\theta$. 
5. Find the group of symmetries for each of the three objects shown below. If you claim a rotational symmetry, indicate the center of the rotation and the angle of rotation. If there are reflections, show the line of reflection. If there are translational symmetries show or describe the vectors of translation.

<table>
<thead>
<tr>
<th>OBJECT</th>
<th>THE GROUP OF SYMMETRIES</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Canadian Flag" /></td>
<td></td>
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<tr>
<td><img src="image" alt="Frieze Pattern" /></td>
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<tr>
<td><img src="image" alt="Reptile Pattern" /></td>
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</tbody>
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[This is a Frieze pattern (the pattern with chickens extends without bounds both to the left and to the right).]