外国語科目 (数理・計算科学専攻)　　18　大修

英語　　時間　午後2時 – 午後3時

注意事項

1. つぎの3問中2問を選択し解答せよ.
2. 解答は1問ごとに別々の解答用紙に記入せよ.
3. 解答用紙ごとに必ず問題の番号および受験番号を記入せよ.
4. 2問を超えて解答した場合は採点されない可能性がある.

問 1

次の英文は，「ブートストラップ」と呼ばれる統計手法の入門書の一部を抜粋したものである．これを読んで下の（1），（2）に答えよ．

> Statistics is a subject of amazingly many uses and surprisingly few effective practitioners. The traditional road to statistical knowledge is blocked, for most, by a formidable wall of mathematics. Our approach here avoids that wall. The bootstrap is a computer-based method of statistical inference that can answer many real statistical questions without formulas. Our goal in this book is to arm scientists and engineers, as well as statisticians, with computational techniques that they can use to analyze and understand complicated data sets.

The word "understand" is an important one in the previous sentence. This is not a statistical cookbook. We aim to give the reader a good intuitive understanding of statistical inference.

One of the charms of the bootstrap is the direct appreciation it gives of variance, bias, coverage, and other probabilistic phenomena. What does it mean that a confidence interval contains the true value with probability .90? The usual textbook answer appears formidably abstract to most beginning students. Bootstrap confidence intervals are directly constructed from real data sets, using a simple computer algorithm. <u>This doesn't necessarily make it easy to understand confidence intervals, but at least the difficulties are the appropriate conceptual ones, and not mathematical muddles.</u>

Bradley Efron, Robert J. Tibshirani: An Introduction to the Bootstrap, Chapman & Hall (1993) の序章より．

practitioner ： 実務家
bootstrap ： ブートストラップ
statistical inference ： 統計的推測
variance, bias, coverage ： 分散，偏り，被覆
confidence interval ： 信頼区間

（1） 枠で囲まれた部分を和訳せよ．
（2） This が何を指すかが分かるようにおぎなって下線部を和訳せよ．

問 2

次の英文は，脳の働きを数学的モデルを使って研究することを目的とした著書「Brains, Machines, and Mathematics」(Michael A. Arbib 著，McGraw–Hill Book Company) の序文からの抜粋である．これを読んで，以下の設問に答えよ

There is a variety of properties—memory, computation, learning, purposiveness[1], reliability despite component malfunction—which it might seem difficult to attribute to "mere mechanisms." However, herein lies one important reason for our study: By making mathematical models, we have proved that there do exist purely electrochemical mechanisms which have the above properties①. In other words, we have helped to "banish the ghost from the machine." We may not *yet* have modeled *the* mechanisms that the brain employs, but we have at least modeled *possible* mechanisms, and that in itself is a great stride forward.

There is another reason② for such a study, and it goes much deeper. Many of the most spectacular advances in *physical* science have come from the wedding of the mathematicodeductive[2] method and the experimental method. The mathematics of the last 300 years has grown largely out of the needs of physics—applied mathematics directly, and pure mathematics indirectly by a process of abstraction from applied mathematics (often for purely esthetic reasons far removed from any practical considerations). In these pages we coerce what is essentially still the mathematics of the physicist to help our slowly dawning comprehension of the brain and its electromechanical analogs③. It is probable that the dim beginnings of *biological* mathematics here discernible will one day happily bloom into new and exciting systems of pure mathematics.

[1] purposiveness: 目的を持つこと.

[2] mathematicodeductive: 数学的な演繹の.

(1) 下線部①の「the above properties」とは何か，日本語で説明せよ．

(2) 下線部②の「another reason」とは何か，日本語で説明せよ．

(3) 下線部③を和訳せよ．

問 3

次の説明文に関する以下の設問に答えよ．(Barry Cipra, Erik D. Demaine, Martin L. Demaine, Tom Rodgers 著，*Tribute to a Mathemagician*，A K Peters, 2005 より，出題のため一部を編集．)

(1) Figure 2 の図（①，②，③）を，説明文（本文，図の注釈）に合うように描け．図中に記号や説明文は不要．

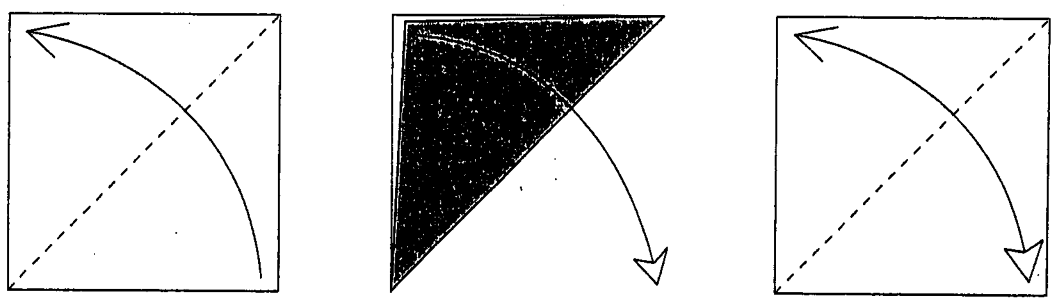
(2) Figure 6 の図（④，⑤）を，説明文等（本文，図の注釈，他の図）に合うように描け．図中に説明文は不要だが，記号は適宜書き入れること．

(3) Hatori's operation (O7) を加えることの利点を英文数行で書け．

Origami, like geometric constructions, has many variations. In the most common version, one starts with an unmarked square sheet of paper. Only folding is allowed: no cutting. The goal of origami construction is to precisely locate one or more points on the paper, often around the edges of the sheet, but also possibly in the interior. These points, known as *reference points*, are then used to define the remaining folds that shape the final object. The process of folding the model creates new reference points along the way, which are generated as intersections of creases with one another or with the folded edge. In an ideal origami *folding sequence*—a step-by-step series of origami instructions—each fold action is precisely defined by aligning combinations of features of the paper, where those features might be points, edges, crease lines, or intersections of same.

Two examples of creating such alignments are shown in Figures 1 and 2. Figure 1 illustrates folding a sheet of paper in half along its diagonal. The fold is defined by bringing one corner to the opposite corner and flattening the paper. When the paper is flattened, a crease is formed that (if the paper was truly square) connects the other two corners.

Figure 2 illustrates another way of folding the paper in half ("book-wise").



1. Fold the bottom right corner up to the top left.

2. Unfold.

3.

Figure 1. The sequence for folding a square in half diagonally.

① ② ③

1. Fold the bottom edge up to the top edge.

2. Unfold.

3. The new crease defines two new points.

Figure 2. The sequence for folding a square in half bookwise.

In both cases, if you unfold the paper back to the original square, you will find that you have created a new crease on the paper. For the sequence of Figure 2, you will also have now defined two new points: the midpoints of the two sides. Each point is precisely defined by the intersection of the crease with a raw edge of the paper.

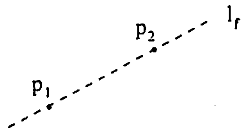
These two sequences also illustrate the rules that we will adopt for origami geometric constructions. The goal of origami geometric constructions is to define one or more points or lines within a square that have a geometric specification (e.g., lines that bisect or trisect angles) or that have a quantitative definition (e.g., a point 1/3 of the way along an edge).

(中略) However, there are several more ways that a fold line can be defined. For example, we can fold a point to another point, fold a line to another line (angle bisection), or put a crease through one or two points, to name a few. Starting in the 1970s, several folders began to systematically enumerate the possible combinations of folds and to study what types of distances were constructible by combining them in various ways. The first systematic study was carried out by Humiaki Huzita [3–5], who described a set of six basic ways of defining a single fold by aligning various combinations of existing points, lines, and the fold line itself. These six operations have become known as "Huzita's Axioms" (HA). Given a set of points and lines on a sheet of paper, Huzita's operations allow one to create new lines; the intersections among old and new lines define additional points. The expanded set of points and lines may then be further expanded by repeated application of the operations to obtain further combinations of points and lines.

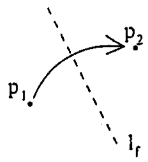
An excellent introduction to "Huzita's Axioms" is given by Hull in [6], and I adopt his notation here. The six operations identified by Huzita are shown in Figure 6.

Recently, a seventh operation was proposed by Hatori [7], which I will denote by O7. It is shown in Figure 7.

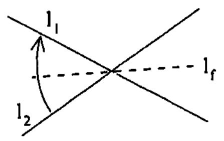
(O1) Given two points p_1 and p_2, we can fold a line connecting them.



(O2) Given two points p_1 and p_2, we can fold p_1 onto p_2.



(O3) Given two lines l_1 and l_2, we can fold l_1 onto l_2.



(O4) Given a point p_1 and a line l_1, we can make a fold perpendicular to l_1 passing through the point p_1.

④

(O5) Given two points p_1 and p_2 and a line l_1, we can make a fold that places p_1 onto l_1 and passes through the point p_2.

⑤

(O6) Given two points p_1 and p_2 and two lines l_1 and l_2, we can make a fold that places p_1 onto l_1 and places p_2 onto l_2.

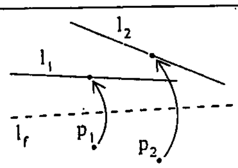


Figure 6. The six operations of "Huzita's Axioms."

(O7) Given a point p_1 and two lines l_1 and l_2, we can make a fold perpendicular to l_2 that places p_1 onto line l_1.

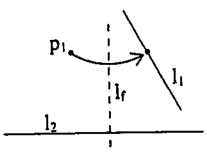


Figure 7. Hatori's seventh axiom.

Hatori noted that this operation was not equivalent to any of HA. Hatori's O7 allows the solution of certain quadratic equations (equivalently, it can be constructed by compass and straightedge). If we denote the expanded set as the "Huzita-Hatori operations" (HH operations), it can be shown that this set is complete, that is, these are all of the operations that define a single fold by alignment of combinations of points and finite line segments.