平成１５年度東京大学大学院理学系研究科
物理学専攻修士課程入学試験問題

英　語　・　数　学

平成１４年８月２７日（火）　　９時００分～１１時００分

【注意事項】

1．試験開始の合図があるまで、この問題冊子を開いてはならない。

2．解答には、必ず黒色鉛筆（または黒色シャープペンシル）を使用すること。

3．問題は全部で４問ある。４問のすべてに解答せよ。

4．答案用紙は数学２枚、英語２枚（罫線入り）が配布されていることを確かめること。

5．数学の解答は２枚とじ解答用紙に記入し、１問ごとに別のページを用いること。英語の解答は罫線入りの２枚とじ解答用紙に記入し、同じく１問ごとに別のページを用いること。

6．各答案用紙の所定欄に**科目名**(数学または英語)、**受験番号、氏名、問題番号**を記入すること。

7．答案用紙は点線より切り取られるから、裏面も使用する場合には、点線の上部を使用しないこと。

8．答案用紙には解答に関係ない文字、記号、符号などを記入してはならない。

9．解答できない場合でも、答案用紙に科目名・問題番号・受験番号および氏名を記入して提出すること。

10．答案用紙を草稿用紙に絶対使用しないこと。

数学

[第1問]

定数ベクトル $\vec{v} = \begin{pmatrix} 2 \\ 1 \\ -1 \end{pmatrix}$ を用いた微分方程式

$$\frac{d}{dt}\vec{x} = \vec{v} \times \vec{x}$$

を考える。

(1) 上の方程式を行列 A を用いて

$$\frac{d\vec{x}}{dt} = A \cdot \vec{x}$$

という形に書き換える。行列 A を求めよ。

(2) 次の性質を持つ正規直交基底 $\vec{e}_i$ $(i = 1, 2, 3)$ $(\vec{e}_i \cdot \vec{e}_j = \delta_{i,j})$ と係数 λ $(\lambda > 0)$ を求めよ。

$$\vec{v} \times \vec{e}_1 = \lambda\,\vec{e}_2, \qquad \vec{v} \times \vec{e}_2 = -\lambda\,\vec{e}_1, \qquad \vec{v} \times \vec{e}_3 = 0$$

ただし $\vec{e}_1$ の第1成分は0とする。

(3) 上で得られた結果を用いると、行列 A は実直交行列 U を用いて

$$A = U \begin{pmatrix} 0 & -\lambda & 0 \\ \lambda & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix} U^t, \qquad UU^t = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

とかけることを示せ (ただし U^t は U の転置行列)。また U を求めよ。

(4) $\vec{x}$ を基底 $\vec{e}_i$ を用いて

$$\vec{x} = \sum_{i=1}^{3} q_i(t)\vec{e}_i$$

と展開する。係数 $q_i(t)$ に対する微分方程式を書き下し、その一般解を求めよ。また解の振る舞いを定性的に論じよ。

1

数学

球対称の関数 $u(t,r)$ に対する波動方程式は、以下のように書くことができる:

$$\frac{\partial^2 u}{\partial t^2} = c^2\left(\frac{\partial^2 u}{\partial r^2} + \frac{2}{r}\frac{\partial u}{\partial r}\right).$$

ここで、r は動径座標、t は時間座標、c は速度の次元の定数である。以下の問に答えよ。

(1) 上の偏微分方程式の一般解を求めよ。なおここで一般解とは2個の任意関数であらわされた解を指す。

(2) 初期条件、$t=0$ で $u = e^{-r^2/(2r_0^2)}$、$\partial u/\partial t = 0$ の場合の $t>0$ に対する解を求めよ。ただし、r_0 は波束の広がりをあらわす実定数である。

(3) 初期条件、$t=0$ で $u = 0$、$\partial u/\partial t = e^{-r^2/(2r_0^2)}$ の場合の $t>0$ に対する解を求めよ。

(4) (3) で求めた関数を、時間に対してフーリエ変換せよ。ただしここでフーリエ変換は、

$$U(\omega, r) = \int_{-\infty}^{\infty} u(t,r)e^{i\omega t}dt$$

と定義する。

(5) $g(\omega) \equiv U(\omega, r=0)$ は、ω の関数である。$g(\omega)$ が最大値となる ω の値を求めよ。

英語

Scientific understanding has probably ⎡(a)⎤ more in the past 50 years than in all previous history. Its applications have made our lives ⎡(b)⎤. Increasingly, however, we recognize unintended ⎡(c)⎤ consequences of our well-intentional activities.

In the United Kingdom, and in Europe more generally, every week seems to bring a new ⎡(d)⎤, report, or debate on "science and society". And a good thing too. I believe we need to do a better job of deliberately asking what kind of world we want – subject to the opportunities offered by scientific advances and the constraints that science clarifies – rather than just letting things happen. A recent ⎡(e)⎤ shows that 84% of Britons think that "scientists and ⎡(f)⎤ make a valuable contribution to society" and 68% think that "scientists want to make life better for the average person". But the real issue, as the same ⎡(g)⎤ showed, is that roughly 50% thought that the pace of current scientific advance was too fast for ⎡(h)⎤ to keep up with through effective ⎡(i)⎤ and regulation. So how best to conduct the dialogue, as old as democracy itself, between government ⎡(j)⎤ and the public in complex scientific areas, in a way that fosters trust?

I begin with the principles set out by the UK office of Science and Technology into the history of bovine spongiform encephalopathy[注1]: Consult widely and get the best people, but also make sure dissenting voices are heard; recognize and admit uncertainly; and above all, be open and publish all advice. Try to separate risk assessment from risk management, and aim at management that is proportional to the risk involved. Whenever possible, make the facts and uncertainties clear and leave it to individuals to choose (for instance, whether to eat beef off the bone or not).

All this is easier said than done. Even when risk can be assessed, people's subjective views may be different (people feel that cars are safer than trains, even though they are more than a hundred times more dangerous). （ア）そして，問題はしばしば既知の科学の枠外にあり，リスクは推測するしか仕方がない。学校，大学，クイズ番組[注2]などを通じ，確立された知識に基づき確実に答えを出せるもの，として科学をとらえている一般市民にとって，このことは特に受容しがたい。It is easy to say "let all voices be

heard", but many will bring other agendas to the debate, and the resulting babble of voices is uncomfortable for a civil servant used to confidential, anonymous, and consensual advice to a minister. However, these admitted and awkward costs of wide and open consultation, and of open admission of uncertainty, are outweighed by their trust-promoting benefits. And anyway, the world that deferred to authority, advised by confidential cabals, has gone. I do not mourn its passing.

I see the recent UK debate and decision about extending the limited use of embryonic stem cells[注3] from research on human fertility[注4] to other specified therapeutic[注5] uses as a model for the （イ）above principles in action. There were three years of wide-ranging debate, engaging scientists, lawyers, ethicists, patient groups, and the general public in its many forms. Then free votes (not constrained by party positions) in both the Lower and Upper Houses of Parliament, against a background of lobbying for and against; much technical information and misinformation; medical benefits for some; and ethical anguish for others. Clear decisions (by more than 2 to 1 in both houses) were made to allow the research to proceed, under well-specified constraints. （ウ）This is democracy in action, notwithstanding the complexity of the science.   adapted from Science 292 2001.

注1:bovine spongiform encephalopathy-牛海綿状脳症（いわゆる狂牛病），注2:クイズ番組-quiz shows，注3:embryonic stem cells-胚幹細胞，ES 細胞，注4:fertility-不妊治療，注5:therapeutic-治療の

(i)　　(a) から (j) までの空欄には，以下のどの語を入れるのが適当か，選択せよ（同じ語が複数の欄に入ることもある）。
1) policymakers, 2) engineers, 3) poll, 4) committee, 5) better, 6) shrinked, 7) oversight, 8) expanded, 9) worse, 10) adverse, 11) effective, 12) government, 13) election, 14) scientists

(ii)　　下線部（ア）を英訳せよ。

(iii)　　下線部（イ）が指し示す 'principles' とは何か，日本語で簡潔に箇条書きせよ。

(iv)　　下線部（ウ）の 'This' の内容を，日本語1行程度で要約せよ。

4

[第2問] 次の説明文を読み，設問 (i)–(iv) に答えよ (配点 40 点)

Time spectroscopy involves the measurement of the time relationship between two events. A particularly difficult problem in timing is to obtain a logic signal[注1] that is precisely related in time to the event. Some type of time pickoff circuit[注2] is employed to produce a logic output pulse that is consistently related in time to the beginning of each input signal.

To understand the use of timing electronics it is important to understand some of the problems associated with timing. Three important sources of error can occur in time pickoff measurements: walk, drift, and jitter. Walk is the time movement of the output pulse relative to its input pulse, due to variations in the shape and the amplitude of the input pulse. Drift is the long-term timing error introduced by component aging and by temperature variations in the time pickoff circuitry. Jitter is the timing uncertainty of the pickoff signal that is caused by noise in the system and by statistical fluctuations of the signals from the detector.

A leading-edge method, which is the simplest means of deriving a time pickoff signal, produces an output logic pulse when the input signal crosses a fixed threshold level. A primary disadvantage of this technique is that the time of occurrence of the output pulse from a leading-edge trigger is a function of the amplitude and rise time[注3] of the input signal. This time walk relationship restricts the usefulness of the leading-edge trigger as an accurate time pickoff device to those applications that involve only a very narrow range of input signal amplitudes and rise times.

(adapted from EG&G ORTEC catalog)

注 1:logic signal–論理信号, 注 2:time pickoff circuit–タイミング信号生成回路, 注 3:rise time–立ち上がり時間

(i)　正確なタイミング測定で問題となる三つの要素を日本語で簡潔に説明せよ。

(ii)　どんな信号に対してリーディング・エッジ (leading-edge) 法が適用できるかを日本語で述べよ。

(iii) 文中の下線部を和訳せよ。

(iv) 次の図は 'walk' を説明するための図である。図中のキーワード (t_1, t_2, V, pulse#1, pulse#2) をすべて用いて，'walk' を英語 5 行以内で説明せよ。