RADLEY COLLEGE
Entrance Scholarships

SCIENCE AND TECHNOLOGY I

Thursday 14th February 2002

Time allowed - 2 hours

*Answer **all** questions.*

All four sections carry equal marks
Allow 30 minutes for each section.

Write the answers to each section
on a separate sheet of paper.

Physics

These questions deal with tiny robots called Nanobots. Scientists think that these may have a number of uses in the future, including spying and medical uses (where the nanobots perform measurements and surgery inside the body).

1. An model of a nanobot used for development is 1000 times bigger than the real nanobot in every direction. It is made of the same materials as the real nanobot.

a. If the model is 0.7m long, how long is the nanobot in m? [1]

The 'foot' of the model is a rectangle with sides 3cm by 4cm

b. What is the area of the model foot in cm^2? [1]

c. What is the area of the model foot in m^2? [1]

d. What is the area of the actual nanobot foot in m^2 [1]

The volume of the nanobot is 0.17 m^3

e. What is the volume of the actual nanobot? [2]

f. So how many times smaller will the mass of the nanobot be, compared with the model? [1]

g. Comment on how the pressure applied by the foot of the model will be different from the real nanobot. [2]

2. One nanobot is designed for spying. It can ‘float’ on air moving upwards. A suggested use is for the nanobot to hover over an enemy camp and transmit the sounds recorded there back to a spy using radio signals.

a. Why does hot air rise? [2]

b. Why might the nanobot be able to float over the enemy camp? [1]

The nanobot floats 10m above the camp. The spy with the radio receiver is 750m from the camp. The speed of sound in air is 330m/s. The speed of radio waves is 3×10^8 m/s.

c. How long does it take for sound to travel from the camp to the nanobot? [2]

d. How long does it take for the radio signal to travel from the nanobot to the spy? [2]

The spy hears that the enemy have discovered his location and are sending a tank to get him.

e. How long do you think it will take the tank to arrive? (use an estimate of the tank’s speed in your answer) [2]

f. How far do you think the spy could get on foot in this time? [2]

3. A different nanobot is being designed to be injected into a person’s blood to stop internal bleeding. When it arrives at a wound, it heats broken blood vessels to seal them. This might be done with an electric current.

a. Why do wires become hot when a current passes through them? [2]

b. The heating wire has to be designed. Should it be short and fat, or long and thin in order to heat up the most? State the reasons for your choice. [3]

Design & Technology

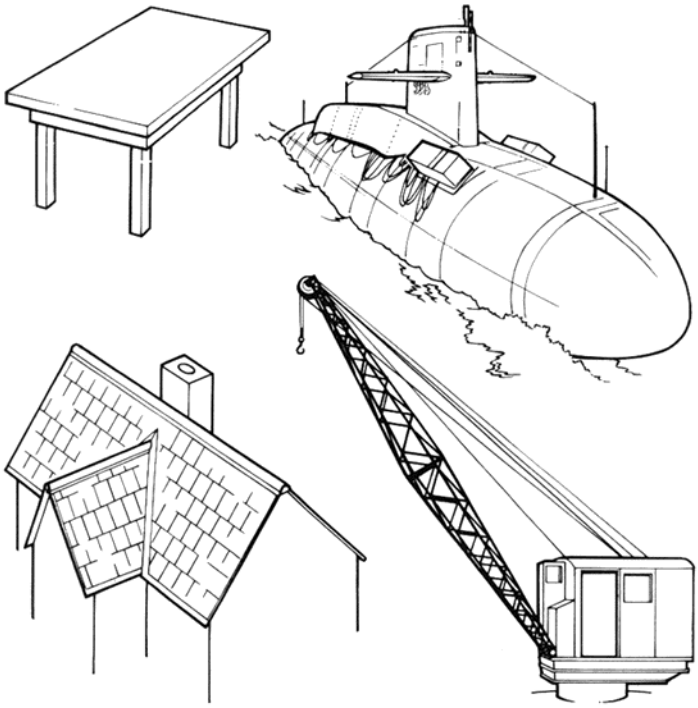
1. Give an example of a man made structure. [1]

2 Give an example of a natural structure. [1]

3. What characteristics do both natural and man-made structures have in common? [3]

4. Explain the term "strength to weight ratio" [2]

Look at the following structures.



5. State which ones are **frame** structures and which ones are **shell** structures.

a) A **table** is an example of a _____ structure.
b) A **submarine** is an example a _____ structure.
c) A **roof** is an example of a _____ structure.
d) A **crane** is an example of a _____ structure.

[4]

6. Forces that act upon the bike shown below include: -

Torsion, Shear, Bending, Compression, Tension.

State which **one** of the forces listed above will have **the greatest effect** upon the following components: -

a) Frame tubes.

b) Chain

c) Pedal crank

d) Spokes

e) Rims

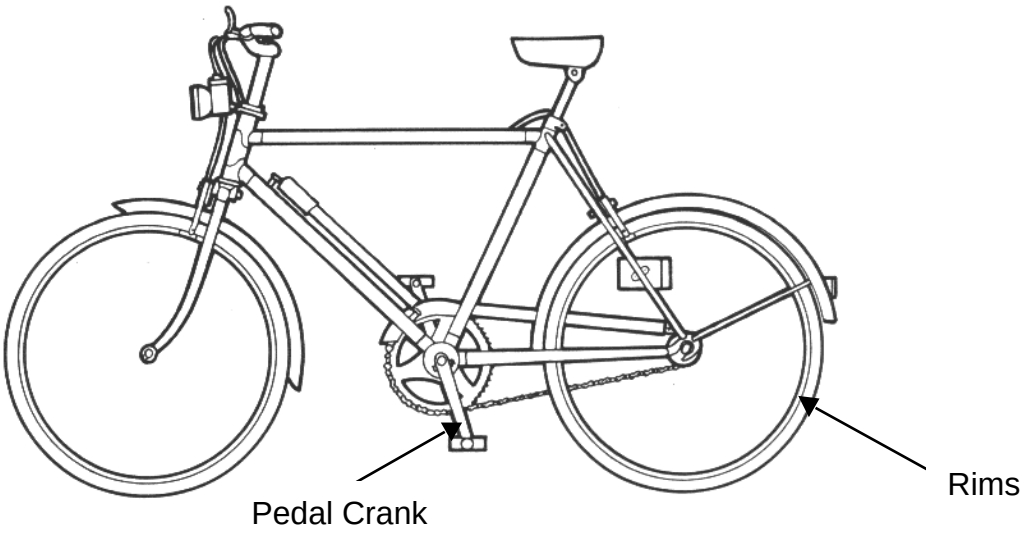
f) Brake Blocks

g) Brake Cable

[7]

7. For each of the above components, suggest a material from which the component would normally be manufactured.

[7]



Biology

Read the following passage which is adapted from: *The Trials of Life* by David Attenborough:

The task of finding enough food for their offspring dominates the lives of most parents during the **breeding season**. Sometimes and in some places, the labour is so time-consuming that even the most hard-working of parents cannot manage it unaided.

In Florida, scrub-jays tackle it as a family team. They live in oak **scrub**, harsh country that is poor both in food (e.g. caterpillars) and nest sites. It is not only the breeding pair that occupies the **territory** around a nest. Several young adults hatched there during the last two breeding seasons live there as well. They assist their parents in feeding their new younger brothers and sisters and in defending them from predators such as snakes. The majority of these helpers are young males. The young females tend to fly off and look for **mates** elsewhere. If the group is really successful and energetic, they may be able to expand the family property. Eventually it may become so big that one of the young sons may be able to set up on his own in one corner of it He will then be in a good position to take over much of the rest of the property when his parents die. But about half of these helpers will never breed. Their lives have been devoted to the welfare of the next generation not, it is true, to their direct descendants, but to their younger brothers and sisters and therefore potentially to their nephews and nieces.

This sort of cooperation within families is much more widespread than was recognised until recently. Moorhens, wrens and woodpeckers all include **species** that, in some circumstances, behave in this way. Ten to fifteen per cent of all the birds in Australia do so as well. And so do some mammals.

Marmosets, tiny monkeys that live in the canopy of the South American rain forest, have a very hard time raising their babies. They have to be constantly on the move, seeking the fruit and insects on which they live, but their babies, usually twins, are particularly large and have to be carried piggy-back until they are quite old. Their mother inevitably expends a great deal of her energy in providing them with milk and the task of carrying them as well is too much for her. So for a lot of the time, their father takes on the job. But even he needs help, for it is not easy to grab an insect or pluck a dangling fruit if you have a couple of half-grown babies on your back. So some of the young of the pair stay with their parents for several years and take turns in transporting the new infants. Father even allows quite unrelated youngsters to join the family group if they will take on some of the work of baby-carrying. As a result, there may be as many as nine adults in one of these family parties. But only one female and male among them breed. The male does sometimes mate with one of the young female helpers but this, for reasons we do not understand, never seems to result in pregnancy.

Using information in the passage and your own knowledge, answer the following questions.

1. What is meant in the passage by the words indicated in bold as follows:
   (i) breeding season
   (ii) scrub
   (iii) mates
   (iv) territory
   (v) species [5]

2. Give an example from the passage of each of the following
   (i) a producer
   (ii) a consumer
   (iii) a reptile [3]

3. Are marmosets herbivores, carnivores or omnivores? [1]

4. To which Kingdom do marmosets belong? [1]

5. To which Phylum do snakes belong? [1]

6. Give two distinguishing features of snakes [2]

7. To which Phylum do insects belong? [1]

8 Give three distinguishing features of insects [3]

9. How does the behaviour of scrub-jays differ from that of cuckoos? [2]

10. Give an example of a complete food chain described in the passage? [3]

11. How does the marmosets' behaviour improve their chances of survival? [3]

Chemistry

1. A mixture containing only oil, common salt, sand and iron filings was found in a school laboratory.

(a) Identify an element and a compound that are present in the mixture. Give the chemical name of the compound. [2]

(b) Describe a method to separate the mixture so that all the constituents can be recovered and used again. Mention any pieces of equipment that may need to be used. **List your method as a series of steps.** [6]

2. The Periodic Table lists all the elements and puts them into two categories separated by a 'zig-zag' line.

(a) What are these two broad categories of elements? [1]

(b) Describe two general physical characteristics that differ between these categories [2]

3. A solid block of an unknown element X was heated and the following results obtained:

Time (s)	0	10	20	30	40	50	60	70	80
Temp (°C)	-60	-40	-39	-1	27	75	107	146	184

(a) Plot a graph of temperature against time. [3]

(b) Identify the point that does not seem to fit with the others. [1]

(c) This result was found to be a misreading of the thermometer. Estimate what the correct temperature should be at that time. [1]

(d) Join the points (including your corrected result) in a smooth line. [1]

(e) Using the following terms, label your graph: [2]

melting point **solid state** **liquid state**

(f) Explain briefly the significance of the two different slopes on the graph. [2]

(g) In a separate test the unknown element X is found to be a good conductor of electricity. Suggest what element X could be. [1]

4. A piece of magnesium was left in a beaker of water for a month.

A test tube was positioned over the magnesium to collect any gas that might be produced.

Some gas was collected in the test-tube, but there was only enough gas collected to perform one test to identify it.

(a) What is the name of the gas collected? [1]

(b) Describe a chemical test that you would carry out to confirm your prediction. [1]

(c) Five drops of universal indicator solution were added to the beaker of water at the end of the month. What colour did the indicator turn? [1]