Family name: _____

Other names: _____

Student ID _____

UNIVERSITY OF TECHNOLOGY SYDNEY

THIS PAPER MUST NOT BE REMOVED FROM THE EXAMINATION CENTRE

AUTUMN SEMESTER EXAMINATIONS 2013

FACULTY OF SCIENCE

SUBJECT NAME:	FOUNDATIONS OF PHYSICS
SUBJECT No:	68101
Date:	THURSDAY 20 JUNE 2013
Time:	2pm to 4.10pm

This paper was designed to be completed in 2 hours. An extra 10 minutes have been added to the time allowed and it is recommended that you use this time to read the paper before commencing to answer the questions.

ATTEMPT ONLY FOUR QUESTIONS
ANSWER EACH QUESTION IN A SEPARATE BOOKLET

CLEARLY MARK THE QUESTION NUMBER ON THE FRONT OF EACH BOOKLET

Calculators may be used.

A formula sheet is provided at the end of the question paper.

SECTION 1: LABORATORY

QUESTION 1

A group of students have conducted an experiment to determine the characteristics of a spring. Hooke's Law indicates that the spring extended from equilibrium by a distance x will exert a restoring force F, that is described by the equation,

$$F = -kx$$

The students make one set of measurements and generate a set of data points, which they tabulate and plot. Their results are shown in the table and graph that is printed at the back of this paper. Use this table and graph, together with your knowledge of experimental physics, to answer the following tasks.

(i) Draw the line of best fit on the graph and determine your best value for k.

[4 marks]

(ii) Draw additional lines on the graph as you see fit and determine the uncertainty in your value of k.

[4 marks]

(iii) Comment briefly on the graph produced by the students indicating
   a. Any issues you see with their graph and table
   b. Steps they should take to improve their estimate of k

[4 marks]

One of the students suggests using only the data for 0.5 N and below because they are concerned about a discontinuity in the graph.

(iv) What would be your reasoned response to such a suggestion and how would such action affect the answer?

[3 marks]

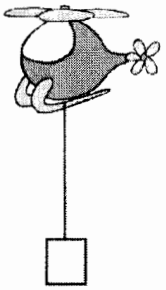
(v) Based on your experience in the laboratory over the semester, what is most important characteristic of good, professional laboratory practice?

[5 marks]

Tear out the graph page from this exam paper, write your name and student number on it and insert it in the exam booklet for this question

SECTION 2: MECHANICS

QUESTION 2



a) A National Parks helicopter is lifting a 400 kg package of gravel and sand to a remote site at the end of a 10m cable. As it passes over a car, its speed is 10 m s^{-1} and the helicopter is at a height of 200m above the ground. At that point, the cable breaks and the load falls to the ground. The pilot continues without altering velocity.

(i) How long will the package take to fall to the ground?
(ii) What is the position of the impact relative to the helicopter? (Below/behind/ahead)?
(iii) What is the total kinetic energy of the package when it hits the ground?
(iv) What happens to this kinetic energy in the impact?

[8 marks]

b) A 9 000 kg locomotive is observed while pulling a set of carriages (total mass 48 000 kg) to accelerate at 1.10 m s^{-1}. If the train was pulling half the number of carriages, and given that the locomotive generates the same overall driving force:

(i) What is the velocity of the train after 10 seconds if it starts from rest?
(ii) What is the total momentum of the train at this time?

[5 marks]

After settling at a velocity of 10 m s^{-1} the train then collides with a stationary locomotive on the track (mass 9 000 kg) and the combination continues along the track as a single unit.

(iii) What is the velocity of the new combination?
(iv) What is meant by the terms elastic and inelastic when applied to collisions?
(v) Is this collision elastic or inelastic?

[7 marks]

[Useful data: $g = 9.8\ m\ s^{-2}$]

SECTION 3: THERMAL PHYSICS

QUESTION 3

The power output of a Bunsen flame is measured to be 320 Watts. In a particular experimental setup, 55% of this power is transferred to 540 g of water which is initially at 21 °C.

i) What will be the temperature of the water after 10 minutes? State any assumptions you made in carrying out your calculations.

[8 marks]

On a particularly sunny day, the solar power per unit area incident on a solar cell is measured as 950 W m^{-2}. The solar cell has dimension 14 cm × 14 cm. The power output of the solar cell in this situation is measured by the technician to be 2.1 W.

ii) What is the value of the efficiency of this solar cell (expressed as a percentage)?

[6 marks]

iii) Suggest two reasons why organic solar cells might be preferred over silicon solar cells for converting the energy from the sun into electrical energy.

[6 marks]

[useful data: Specific heat capacity of water = 4190 J kg^{-1} $°C^{-1}$]

SECTION 4: WAVES AND RESONANCE

QUESTION 4

The figure below shows the adsorption spectrum for gold nanoparticles, varying in size from 20 nm to 400 nm in diameter, as a function of wavelength of the incident light. These adsorption spectra are examples of resonance curves. Explain what you understand by the term 'resonance' and how resonance gives rise to these adsorption spectra.

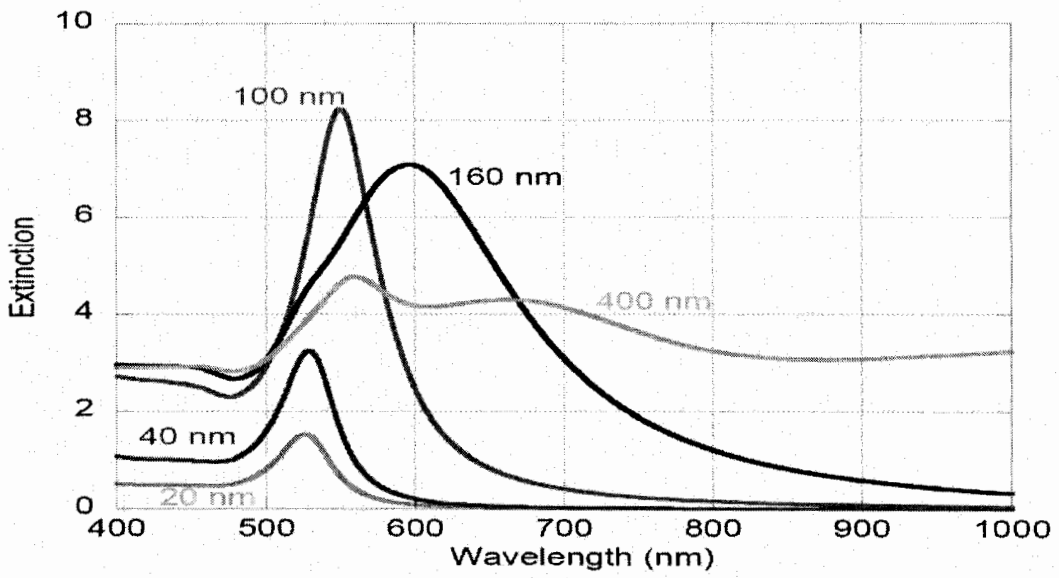
Guidelines and Instructions

For a pass level answer you could describe in qualitative terms your understanding of resonance and its manifestation in the adsorption curves.

For a higher mark in this question you will need to demonstrate you understand the underlying mathematical description of resonance.

Your answer needs to be less than one page. Anything over one page will be ignored in the marking process.

[20 marks]



SECTION 5: ATOMS AND GASES

QUESTION 5

a) With reference to an ideal gas such as helium or oxygen, answer the following questions in a paragraph or two. Include relevant equations and diagrams and explain any equations and symbols used.

i) What is the relationship between pressure, temperature and volume of an ideal gas?
[4 marks]

ii) Under what conditions are gases able to do thermodynamic work?
[4 marks]

iii) How does the rms speed of the gas molecules relate to their average kinetic energy and the internal energy of the gas?
[4 marks]

b) After the intake stroke, the 2 litre cylinder of a particular internal combustion engine contains a mixture of 20% ethanol vapour (C_2H_5OH) and 80% oxygen gas at atmospheric pressure and room temperature (20°C). This gas mixture is compressed to a tenth of the cylinder volume and then ignited at 500°C, resulting in an ethanol combustion reaction accompanied by gas expansion.

The power stroke occurs under isothermal conditions (T=500°C). After this, the gaseous products and excess heat produced as a result of the combustion reaction are then exhausted from the cylinder through an exhaust valve.

i) Illustrate the power stroke of this engine on a properly labelled P-V diagram.
ii) How many moles of the fuel mixture are present in the cylinder after the intake stroke?
iii) What is the work done by the expanding gas?

[8 Marks]

[Useful data: $k = 1.38 \times 10^{-23}$; R= 8.314 J mol^{-1} K^{-1}]

USEFUL FORMULAE

$$F = ma$$

$$k.e. = \tfrac{1}{2}mv^2$$

$$p.e. = mgh$$

$$\tfrac{1}{2}m\overline{v^2} = \tfrac{3}{2}kT$$

$$\sum_{before} m_i v_i = \sum_{after} m_i v_i$$

$$s = ut + \tfrac{1}{2}at^2$$

$$v^2 = u^2 + 2as$$

$$v_{rms} = \sqrt{\frac{3kT}{m}}$$

$$p = mv$$

$$Q = mc\Delta T$$

$$Q = mL_f$$

$$c_p - c_v = R$$

$$v = u + at$$

$$W = \int_{v_i}^{v_f} P\,dV$$

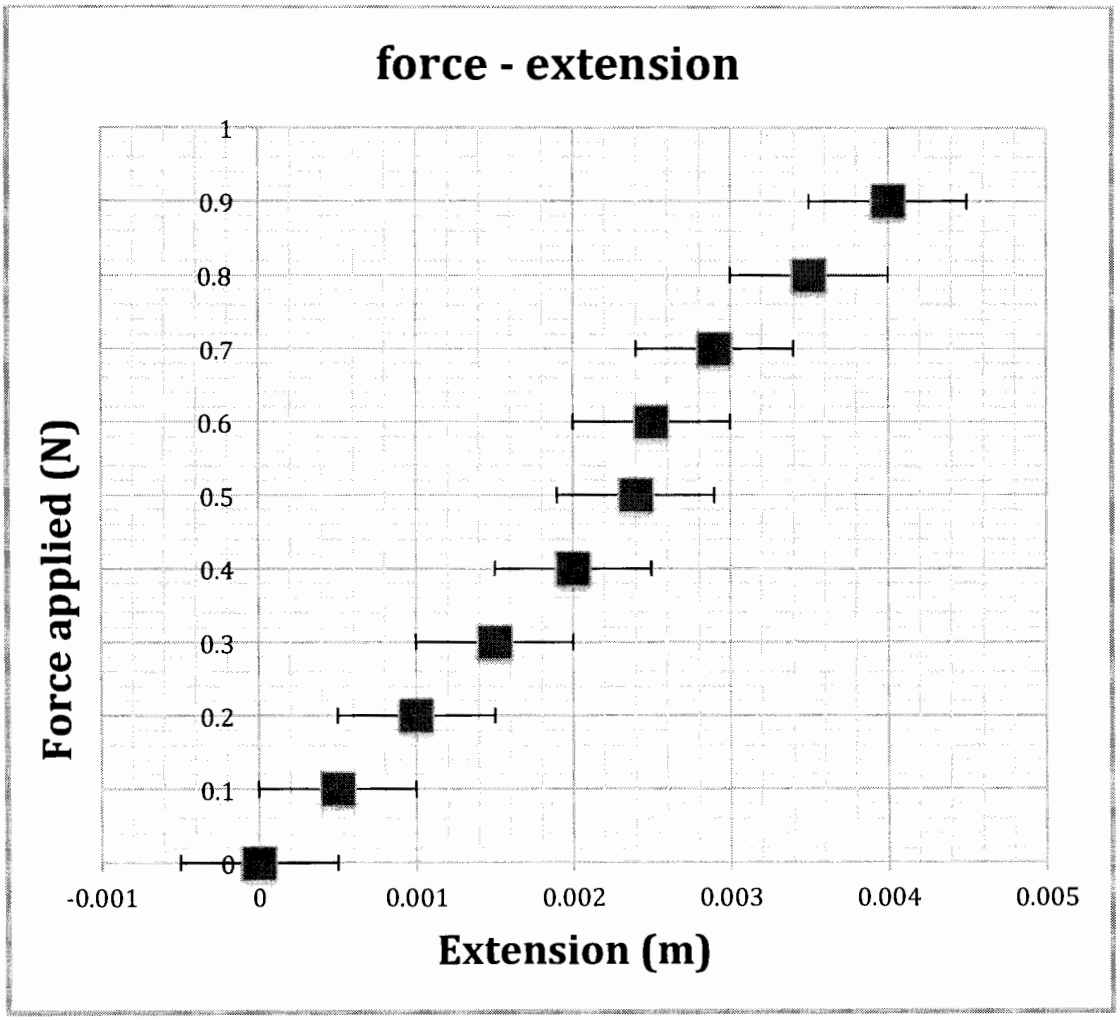
$$Q = -kA\frac{dT}{dx}$$

$$PV = nRT$$

$$W = nRT\ln(V/V_o)$$

APPENDIX 1: EXPERIMENTAL RESULTS FOR QUESTION 1

Force (N)	Extension (m)
0	0
0.0005	0.1
0.001	0.2
0.0015	0.3
0.002	0.4
0.0024	0.5
0.0025	0.6
0.0029	0.7
0.0035	0.8
0.004	0.9



NAME:_____**STUDENT NUMBER:**_____

[END OF EXAM PAPER]