NEW ZEALAND QUALIFICATIONS AUTHORITY
MANA TOHU MĀTAURANGA O AOTEAROA

No. 262

Marking Schedule and Examination Commentary 2001

University Entrance, Bursaries and Scholarships Examination

PHYSICS

University Entrance, Bursaries and Scholarships Examination
PHYSICS 2001

Marking Schedule and Examination Commentary

General Comments

The 2001 paper was similar in style to those in recent years and appeared to be more straightforward and accessible than the 2000 paper. Candidates were able to show what they knew, not just what they were able to interpret. This is very relevant given the type of candidate now attempting this subject. Well-prepared candidates were able to achieve more than 135 marks. As usual the paper was based on contextual algebraic and descriptive questions. Nearly all the candidates appeared to finish the paper earlier than the allocated time, with sufficient time left to thoroughly check their answers. The general standard of the understanding of physics theory was pleasing.

There were many 'show that' questions and these were handled well by most candidates. Some candidates still need considerable practice in this type of question. Simple, clear setting out is very important in this type of question.

Questions requiring descriptive answers were not well done. Some candidates were very poor at writing answers in simple, clear English and they need to take more time on these parts of the paper. Candidates need considerable time in the classroom to assist them to improve in this area.

There appeared to be no major area of the prescription that was not adequately done by candidates but the following areas could do with some attention:
- the reference circle in SHM
- the idea of change in momentum
- definitions of physics concepts/ideas or terms such as 'longitudinal and transverse waves'
- the harmonic series in one-end closed pipes
- the drawing of simple graphs such as capacitor charging
- the concept of binding energy
- the concept of impedance
- the photoelectric effect and wave particle duality
- the concepts of current and voltage.

Units were handled well by most candidates with a mean score of two out of four. The only units consistently poorly done were those of rotational inertia, magnetic flux and impedance. Significant figures continue to be done poorly with most candidates losing all four marks very early on in the paper. The mean mark for significant figures was 0.8 out of 4.

Considerable revision of significant figures is required to lift this mean in the future.

The general presentation of candidate responses was acceptable but still a large number of candidates present their responses very poorly. Unfortunately, the legibility of some scripts was appalling. Candidates need to be aware that care must be taken to present a clear, tidy script which is easy to read. The use of pencil was still widespread. Candidates are strongly advised not to use pencil.

Comments on Specific Questions

Note: the mean mark in each case has been obtained from a sample of papers and is unscaled.

Question One: The Spinning Yo-Yo (mean 10.1/14)

As in earlier years, Question One was supposed to be reasonably straightforward in order to settle candidates into the examination.

(a) Well done by most candidates. A reasonable proportion had problems with the significant figures.

(b) Well done.

(c) Well done by most candidates. A reasonable proportion had problems with the significant figures.

(d) Well done.

(e) Well done.

(f) Many handled this well but a significant number tried to use $I = mr^2$. Units and significant figures were handled poorly by many candidates.

(g) Very few candidates gained full marks. Many candidates just restated the question and did not make a clear physics statement about rotational inertia and its link to mass.

Question Two: Linear and Rotational Motion (Part 1) (mean 5.4/9)

(a) Well done by most candidates.

(b) Most candidates did not state a clear definition of change in momentum. A good number simply subtracted the two momenta without recognising that they were oppositely directed. Significant figures were often poorly done.

(c) Reasonably well done by most as consequential errors from (b) were allowed. Nearly all candidates lost a significant figure mark as they did not realise the time was only quoted to one significant figure.

(d) While some candidates recognised that the softer material would lead to a longer collision time and a smaller average force (assuming same mass), few candidates qualified this answer with a statement that the change in momentum must be unchanged.

(e) Well done by most. A surprising number did not square the velocity in their calculation of kinetic energy.

Question Two: Linear and Rotational Motion (Part 2) (mean 9.2/12)

(a) Well done by most.

(b) Well done.

(c) Well done.

(d) Well done. Many had problems with the significant figures.

(e) Well done.

(f) Well done by the most able candidates. Many candidates did not set their working out clearly and often used the wrong trig function in their calculations.

Question Three: Simple Harmonic Motion (mean 9.5/17)

(a) Well done by most. Some did not state the relevant equation.

(b) Most candidates recognised both ends of the swing.

(c) Well done. Some tried to use $v = A\omega\cos\omega t$ and failed to recognise that $\cos\omega t = 1$ at maximum velocity.

(d) Many candidates did not state that the total energy was conserved and so $E_{kmax} = E_{pmax}$. A number tried to use $E_p = mgh$ here.

(e) Poorly done by most. Those who were familiar with the reference circle did well. No marks were awarded for finding the correct answer by formula. Many candidates calculated a vertical rather than a horizontal distance from the centre of the swing. A large number did not attempt this question.

(f) Well done by many candidates although poor axis labelling was a problem for many. The maximum acceleration was rarely calculated correctly.

Question Four: The Orchestra (mean 8.6/14)

(a) Generally well done, but a small proportion of candidates managed to draw several wavelengths or a full wave with a node at the open end. Labelling of nodes and antinodes was often poorly done.

(b) Generally well done.

(c) A surprising number of candidates incorrectly answered this as 'transverse'.

(d) (i) A common misconception appears to be that pipes open at one end support even harmonics. Many candidates drew the fifth harmonic. The third harmonic is a frequency multiple, which when applied to a single-ended column, results in $L = 3/4\lambda$.
   (ii) Generally well done by most.

(e) This is an 'explain' question. A number of candidates performed accurate calculations of wavelength and left markers to infer the answer. Some calculated which clarinet was longer. Careful reading of the question is essential. Candidates' explanations were not, in general, particularly clear.

(f) Well done.

Question Five: Interference (mean 6.5/9)

(a) A good number could not define 'monochromatic'.

(b) Well done, but many did not state the appropriate formula.

(c) Many struggled with the rearrangement required for full marks. Clear layout is extremely important. It lets the candidate gain full marks and needs to be modelled and taught as a specific skill.

(d) Many candidates were unable to identify the correct symbol and lost all their marks.

(e) Well done by most, but many misread the question, often writing about the distance increasing.

Question Six: Earthquakes (mean 3.7/6)

(a) Very poorly done by most candidates. Very few candidates could describe the difference between the two types of waves. The general standard of simple English was very low.

(b) (i) and (ii) A surprising number lost both marks. There was poor reading of the resource material.

(c) Well done by most. Significant figures were often a problem.

Question Seven: DC Electricity (mean 7.6/13)

(a) Well done. Most candidates had problems with the significant figures.

(b) Well done.

(c) Well done.

(d) Well done.

(e) Most candidates did not make a 'conservation' statement and therefore very few gained full marks. Many candidates did not attempt this question.

(f) Very few gained full marks. The key idea was that the 18V across the on-board equipment had to remain constant. Many claimed that the resistance (0.4Ω) varied. A number used terms such as 'volts flow through'. This is rather concerning. Candidates' basic knowledge of current and voltage is still of concern.

Question Eight: Capacitors (mean 5.4/10)

(a) Well done by most but many forgot to state which formula they were using.

(b) Not all candidates recognised the correct formula required. Secs is not an acceptable SI unit.

(c) (i) Poorly done. A lot of candidates lost marks because they did not show all of the features of the current versus time graph. Many did not calculate the current correctly. Many thought the current increased with time.

(ii) Poorly done as above. Poor axis labelling again. Many ignored the asymptote all together.

(d) Generally well done provided candidates did not confuse C and Q.

Question Nine: The Wind Turbine (mean 6.4/10)

(a) A large number of candidates answered this incorrectly, giving the position as A instead of B. Allowing for guesswork, the mean mark here suggests that up to 50% of candidates were uncertain of the correct answer.

(b) Well done by most candidates. Units and significant figures were poorly done.

(c) Well done by most candidates.

(d) Reasonably well done by most candidates. Many lost marks by not clearly stating that $\varepsilon = BAN\omega\sin\omega t$ is maximum when $\sin\omega t = 1$.

(e) Well done by most candidates.

Question Ten: AC Theory (mean 10.2/18)

(a) Well done by most candidates. Some failed to state the relevant equation.

(b) Generally well done, but again some candidates did not state the relevant equation.

(c) Well done.

(d) Poorly done. Some tried to work backwards from (e). Units were poorly done. Impedance seems to be poorly understood.

(e) Well done by those who had successfully completed (d).

(f) (i) Well done by most. Significant figures were often a problem.

(ii) Well done by the more able candidates. Significant figures were often a problem.

(g) (i) Well done by most.

(ii) A large number were able to clearly explain why the voltage across the resistor decreased.

(h) Poorly done. Many candidates answered ' 90°'. A number of candidates calculated the angle between

the supply voltage and the resistor voltage. Significant figures were often a problem.

Question Eleven: Atomic Physics (mean 5.4/10)

(a) Well done.

(b) Most candidates solved this correctly, although some multiplied the values of hf and ϕ instead of subtracting them.

(c) Poorly done. Many candidates stated the correct formula and had some knowledge of the need for hf to be greater than ϕ but failed to mention the kinetic energy of the emitted electron. Many candidates mentioned the possibility of negative kinetic energy.

(d) Very poorly done. Many candidates restated the previous answer. There was little linking of the intensity of light with the size of the photocurrent. Mention was often made of the implications of changing the wave amplitude but this was not fully discussed.

(e) Reasonably well done.

Question Twelve: Nuclear Physics (mean 5.6/10)

(a) A surprising number lost both marks by transposing the answers.

(b) Well done by most.

(c) Generally well done. Many ignored the physics and simply added a few numbers without showing what they were adding and why.

(d) Generally well done, but many forgot to square the speed of light. Many had problems with the significant figures.

(e) Very poorly done. Only the very best candidates gained more than one mark. Many did not use the graph. A surprising number mentioned orbital electrons. The concept of binding energy is poorly understood.

MARKING SCHEDULE

QUESTION 1: THE SPINNING YO-YO   (14 marks)

(a) 4090 rev /min = 4090/60 rev/second

$$= \frac{2\pi \times 4090}{60} \text{rad s}^{-1}$$ (1 mark)

$$= 428 \text{ or } 428.3 \text{ rad s}^{-1}$$ (1 mark)

(b) $d = r\theta$

$$\theta = \frac{d}{r}$$ (1 mark)

$$\frac{1.20}{4.00 \times 10^{-3}} (= 300)$$ (1 mark)

(c) $\alpha = \frac{\Delta\omega}{\Delta t}$

$$= \frac{428}{1.40}$$ (1 mark)

$$= 306 \text{ rads}^{-2}$$ (1 mark)

(d) $a = r\alpha$ (1 mark)

$$= 4.00 \times 10^{-3} \times 306 = 1.224$$ (1 mark)

$$\left(= 1.22 \text{ ms}^{-2}\right)$$

(e) $\tau = Fr$ (1 mark)

$$= 0.274 \times 4.00 \times 10^{-3}$$ (1 mark)

$$= 1.096 \times 10^{-3} \text{Nm}$$

$$\left(= 1.10 \times 10^{-3} \text{Nm}\right)$$

(f) $\tau = I\alpha$

$$I = \frac{\tau}{\alpha}$$ (1 mark)

$$= \frac{1.096 \times 10^{-3}}{306}$$

$$= 3.58 \text{ to } 3.61 \times 10^{-6} \text{ kgm}^2 \text{ or } Nms^2$$ (1 mark)
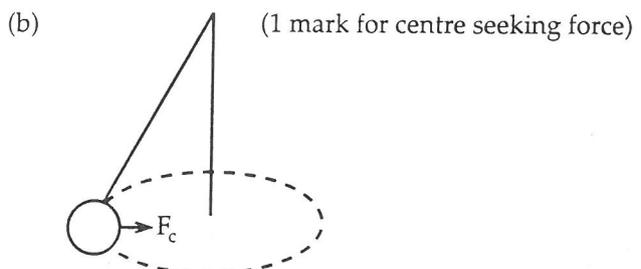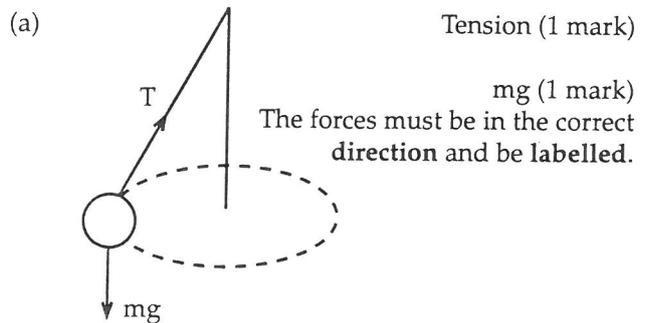
(g) I is less because I depends on mass.   (2 marks)

QUESTION 2: LINEAR AND ROTATIONAL MOTION   (21 marks)

PART 1: Collision Time

(a) $p = mv$

$$= 5 \times 7.3$$ (1 mark)

$$\left(= 36.5 \text{ kg ms}^{-1}\right)$$

(b) $\Delta p = m\Delta v$

$$= m\left(v_f - v_i\right)$$ (1 mark)

$$= 5\left(-2.1 - 7.3\right)$$

$$= -47.0$$

$$= 47.0 \text{ kg ms}^{-1}$$ (1 mark)

(c) $F = \frac{\Delta p}{\Delta t}$ (1 mark)

$$= \frac{47.0}{0.2}$$

$$= 235 \text{ N}$$

$$= 200 \text{ N}(1sf)$$ (1 mark)

(d) Less because change in momentum is the same, longer time means smaller force.   (2 marks)

(e) $E_k\left(\text{before}\right) = \frac{1}{2}mv^2$

$$= \frac{1}{2} \times 5 \times \left(7.3\right)^2$$ (1 mark)

$$E_k\left(\text{after}\right) = \frac{1}{2}mv^2$$

$$= \frac{1}{2} \times 5 \times \left(2.1\right)^2$$ (1 mark)

$$\Delta E_k = 122 \text{ J}\left(\text{loss}\right)$$

PART 2: The Conical Pendulum

(a)   Tension (1 mark)

mg (1 mark)
The forces must be in the correct **direction** and be **labelled**.

(b)   (1 mark for centre seeking force)

(c)
$$f = \frac{1}{T}$$ (1 mark)

$$= \frac{1}{2.16}$$ (1 mark)

$$(= 0.463 \text{ Hz})$$

(d)
$$v = \frac{d}{t}$$

$$= \frac{2\pi R}{T}$$ (1 mark)

$$= \frac{2\pi \times 0.310}{2.16}$$

$$= 0.902 \text{ m s}^{-1}$$ (1 mark)

(e)
$$F_c = \frac{mv^2}{r}$$ (1 mark)

$$= \frac{3.2 \times 10^{-2} \times (0.902)^2}{0.310}$$ (1 mark)

$$(= 0.0839 / 0.0840 \text{N})$$

(f)
$$F_c = T\sin 15°$$

$$T = \frac{0.0839}{\sin 15°}$$

$$= 0.324 \ N$$

or $T = \sqrt{(mg)^2 + F_c^2}$

$$= 0.325 \ N$$

Appropriate formula/method (1 mark)
Data and/or correct substitution (1 mark)
Answer (1 mark)
(2 or 3 sf accepted)

QUESTION 3: SIMPLE HARMONIC MOTION
(17 marks)

(a)
$$\omega = 2\pi f$$ (1 mark)

$$= \frac{2\pi}{T}$$

$$= \frac{2\pi}{2.2}$$ (1 mark)

$$(= 2.86 \text{ rad s}^{-1})$$

(b) A and C (1 mark)

(c)
$$v = A\omega$$ (1 mark)
(1 mark)
$$= 0.100 \times 2.86$$

$$(= 0.286 \text{ m s}^{-1})$$

(d)
$$E_k = \frac{1}{2}mv^2$$

$$= \frac{1}{2} \times (3.2 \times 10^{-2}) \times (0.286)^2$$ (1 mark) (working)

E at C $E_k = E_{p \ max} = E_{k \ max}$
(1 mark for indication by words/symbols that $E_p = E_k$)

Energy $= 1.31 \times 10^{-3}$ J (1 mark)

(e)
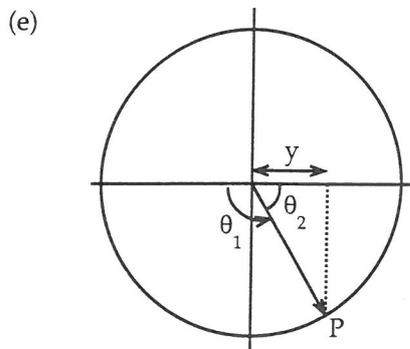
$$\vartheta_1 = \frac{1}{2.2} \times 360° = 163.64° \ (or \ 2.8560 \ rads)$$ (1 mark)

$$y = A\cos\vartheta_2$$

$$= 0.1 \times \cos(16.36°) \ (16.36° = 0.285535 \ rads)$$ (1 mark)

distance $= 0.0959$ m (1 mark)

If candidates use the rounded version of the angular velocity then d = 0.0961 m

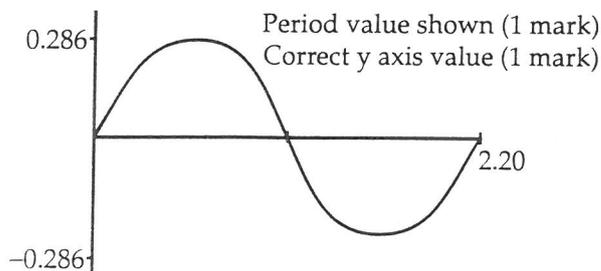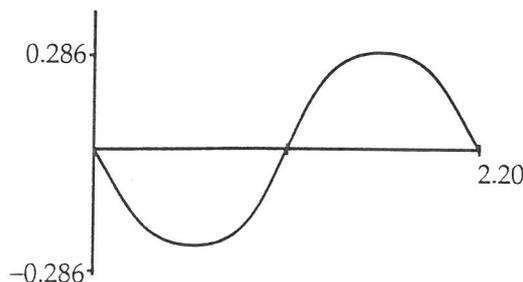Must use reference circle, if not, 0 marks awarded.

(f) (i)   A sine graph (1 mark)

Period value shown (1 mark)
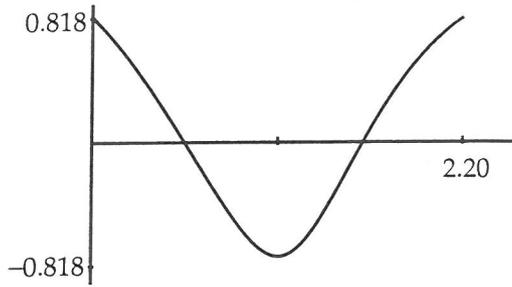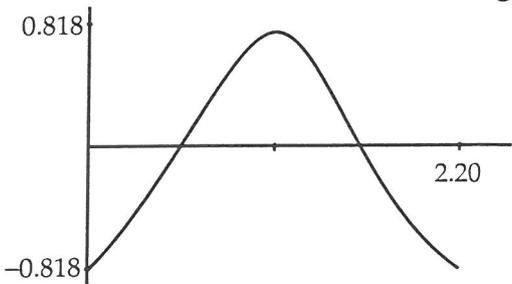Correct y axis value (1 mark)

OR

(f) (ii)

Leads by 90 degrees (1 mark)
Period value shown (1 mark)
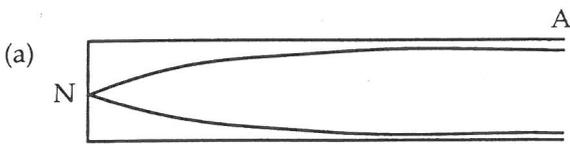A correct y axis value (1 mark)

OR

$$a_{max} = \omega^2 A$$
$$= (2.86)^2 \times 0.1$$
$$= 0.818 \text{ m s}^{-1}$$

QUESTION 4: THE ORCHESTRA   (14 marks)
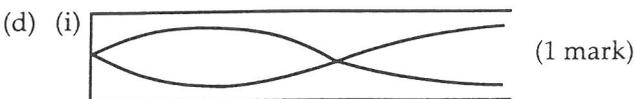
(a)

Shape/representation (1 mark)
Antinode at open end (1 mark)
Node at closed end (1 mark)

(b) $\lambda = 4 \times 0.660$ (1 mark)
        $= 2.64 \text{ m}$ (1 mark)

wavelength = 2.64 m

(c) Longitudinal   (1 mark)

(d) (i)

(1 mark)

(ii) $L = \frac{3}{4}\lambda$

        $\lambda = 0.880 \text{ m}$ (1 mark)

        $v = f\lambda$

        $f = \frac{(3.30 \times 10^2) \times 0.75}{0.660}$ (1 mark)

        $= \text{frequency} = 375 \text{ Hz}$ (1 mark)

(e) Helen's   (1 mark)

        $\lambda \propto L$ (1 mark)

        $f \propto \frac{1}{L} \Rightarrow$ higher frequency is
        shorter instrument   (1 mark)

(f) $\text{beat} = |f_1 - f_2|$
        $= 440 - 430$

        frequency of the beats = 10 Hz   (1 mark)

QUESTION 5: INTERFERENCE   (9 marks)

(a) Single colour/wavelength/frequency   (1 mark)

(b) $c = f\lambda$ (1 mark)

        $f = \frac{c}{\lambda} = \frac{3.00 \times 10^8}{5.70 \times 10^{-7}}$ (1 mark)

        $\left(= 5.26 \times 10^{14} \text{ Hz} \right)$

(c) $n\lambda = \frac{dx}{L}$ (1 mark)

        $d = \frac{n\lambda L}{x}$ (1 mark)

        $= \frac{(5.70 \times 10^{-7}) \times 2}{2 \times 10^{-2}}$ (1 mark)

        $\left(= 5.70 \times 10^{-5} \text{m} \right)$ $\left(d\sin\theta = n\lambda \text{ accepted} \right)$

(d) $x = \frac{n\lambda L}{d}$

        $= \frac{(6.33 \times 10^{-7}) \times 2}{5.70 \times 10^{-5}}$ (1 mark)

        $= 2.22 \times 10^{-2} \text{ m}$

distance = 2.22×10^{-2} m   (1 mark)

(e) Decrease/closer/nearer etc   (1 mark)

QUESTION 6: EARTHQUAKES (6 marks)

(a) p – wave – medium oscillates parallel to the direction of propagation (longitudinal). (1 mark)

s – waves – medium oscillates at right angles to the direction of propagation (transverse). (1 mark)

(b) (i) s and p (1 mark)

(ii) p (1 mark)

(c) $v = \dfrac{d}{t}$ (1 mark)

$t = \dfrac{d}{v} = \dfrac{8.10 \times 10^6 \text{ m}}{11.0 \times 10^3}$

$= 736$

time $= 736$ s (1 mark)

QUESTION 7: DC ELECTRICITY (13 marks)

(a) $V = IR$

$= 11.0 \times 0.400$ (1 mark)

$= 4.40$ V (1 mark)

(b) $V = IR$

$R = \dfrac{V}{I}$ (1 mark)

$= \dfrac{18}{11}$ (1 mark)

$(= 1.64\,\Omega)$

(c) $P = VI$

$= 18 \times 11$ (1 mark)

$= 198$ W (1 mark)

(d) $P = VI$

$= 4.4 \times 11$ (1 mark)

$= 48.4$ W (1 mark)

(e) $V_A + V_B = V_{0.400} + V_R$ (1 mark)

$20 + V_B = 4.4 + 18$ (1 mark)

$(V_B = 2.40\ V)$ (1 mark derived as 2.40 V)

Or alternative power equation versions.

(f) More energy/voltage lost across 0.4 resistor. (1 mark)

Must link constant 18.0 V across R with increasing B to compensate. (1 mark)

QUESTION 8: CAPACITORS (10 marks)

(a) $\dfrac{1}{C_T} = \dfrac{1}{C_1} + \dfrac{1}{C_2} + \dfrac{1}{C_3}$ (1 mark)
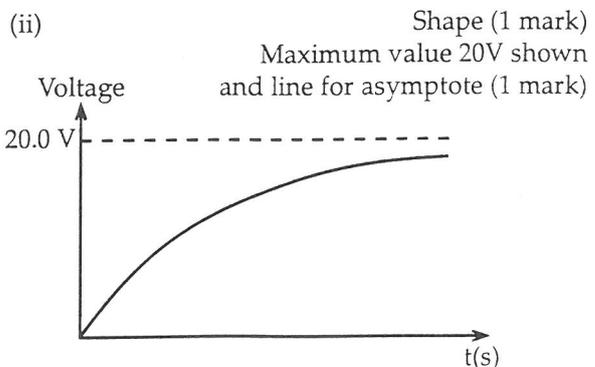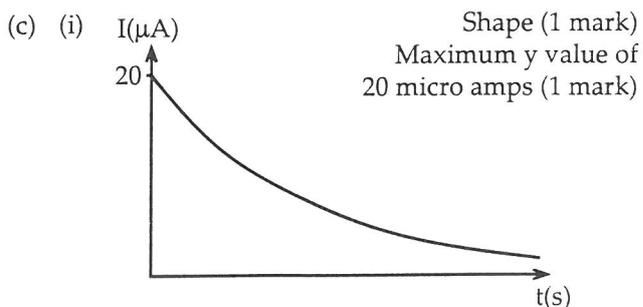
$= \dfrac{1}{10} + \dfrac{1}{20} + \dfrac{1}{30}$ (1 mark)

$(C_T = 5.45\,\mu F)$

(b) $\tau = RC$

$= 1 \times 10^6 \times 5.45 \times 10^{-6}$ (1 mark)

$= 5.45$ seconds (1 mark)

(c) (i) I(μA)   Shape (1 mark)
Maximum y value of
20 micro amps (1 mark)

(ii)   Shape (1 mark)
Maximum value 20V shown
and line for asymptote (1 mark)

(d) $E = \dfrac{1}{2}QV$

$= \dfrac{1}{2}CV^2$ (1 mark)

$= \dfrac{1}{2} \times 5.45 \times 10^{-6} \times 20^2$

$= 1.09 \times 10^{-3}$ J (1 mark)

QUESTION 9: THE WIND TURBINE (10 marks)

(a) B (1 mark)

(b) $\phi = BA = 0.250 \times 1 \times 10^{-2}$ (1 mark)

maximum flux $= 2.50 \times 10^{-3}$ Wb or Tm^2 (1 mark)

(c) $\omega = 2\pi f$ (1 mark)

$= 2 \times \pi \times 1 \times 10^2$

$= 628 \text{ rad s}^{-1}$ (1 mark)

(d) $\varepsilon = B\,A\,N\omega \sin\omega t$ (1 mark)

$(\sin\omega t = 1)$ (1 mark)

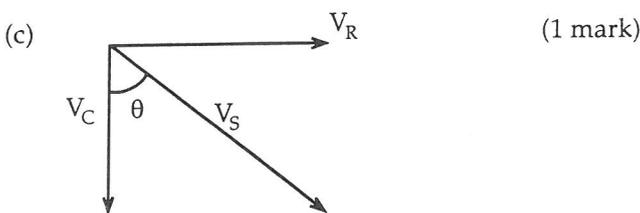$= 0.25 \times 1 \times 10^{-2} \times 500 \times 628.31853$ (1 mark)

$(= 785 \text{ V})$

(e) $V_{rms} = \dfrac{V_{max}}{\sqrt{2}}$

$= \dfrac{785}{\sqrt{2}}$ (1 mark)

rms voltage = 555 V   (1 mark)

QUESTION 10: AC THEORY   (18 marks)

(a) $\omega = 2\pi f$ (1 mark)

$= 2\pi \times 50$ (1 mark)

$(= 314 \text{ rads}^{-1})$

(b) $X_c = \dfrac{1}{\omega C}$ (1 mark)

$= \dfrac{1}{314 \times 1.2 \times 10^{-4}}$ (1 mark)

$(= 26.5\,\Omega)$

(c)   (1 mark)

(d) $Z = \sqrt{X_c^2 + R^2}$ (1 mark)

$= \sqrt{12^2 + 26.5^2}$

$= 29.1\ \Omega$ (1 mark)

(e) $V = IZ$

$I = \dfrac{V}{Z}$ (1 mark)

$= \dfrac{16}{29.1}$ (1 mark)

$(= 0.550 \text{ A})$

(f) (i) $V_R = IR$ (1 mark)

$= 0.550 \times 12$ (1 mark)

$= 6.60 \text{ V or } 6.59 \text{ V}$ (1 mark)

(ii) $V_c = IX_c$

$= 0.550 \times 26.5$ (1 mark)

$= 14.6 \text{ V}$

or $\sqrt{16^2 - 6.6^2}$ (1 mark)

(g) (i) increases   (1 mark)

(ii) the voltage across the resistor drops   (1 mark)

reactance increases, voltage across capacitor increases   (1 mark)

(h) $\theta = \cos^{-1}\left(\dfrac{V_c}{V_s}\right)$ (1 mark)

$= \cos^{-1}\left(\dfrac{14.6}{16}\right)$

$= 24.1°$ (1 mark)

Accept up to 24.6° due to rounding.

QUESTION 11: ATOMIC PHYSICS   (10 marks)
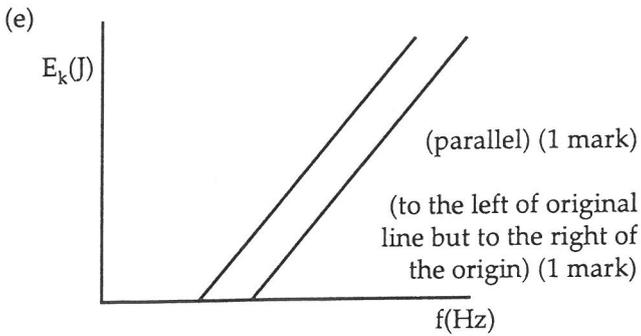
(a) $E = hf$ (1 mark)

$= 6.63 \times 10^{-34} \times 1.05 \times 10^{19}$ (1 mark)

$(= 6.96 \times 10^{-15} \text{ J})$

(b) $E_k = hf - \phi$

$= 6.96 \times 10^{-15} - 9.61 \times 10^{-16}$ (1 mark)

$= 6.00 \times 10^{-15} \text{ J}$ (1 mark)

(c) $hf = \phi + E_k$ or $hf \geq \phi$ (1 mark)

The frequency of the photons must be great enough that their energy is greater than the work function of the metal, so that the electrons have some kinetic energy.   (1 mark)

(d) E_k is proportional to frequency (via $E = hf$)   (1 mark)

Higher intensity releases more of the same energy.   (1 mark)

OR

If argued from the wave perspective, E_k is proportional to intensity.

Higher intensity would release higher energy electrons but this contradicts experimental evidence.

(e)

E$_k$(J)

(parallel) (1 mark)

(to the left of original line but to the right of the origin) (1 mark)

f(Hz)

QUESTION 12: NUCLEAR PHYSICS   (10 marks)

Part 1: The Smoke Detector

(a)   A = -1   (1 mark)
      B = 0   (1 mark)

(b)   Electron or beta particle.   (1 mark)

(c)   Addition of mass of Np and He   (1 mark)
      ($4.0024765 \times 10^{-25}$ kg)
      Subtraction of above to get 1.013×10^{-29} kg
                                      (1 mark)

(d) $E = mc^2$ (1 mark)

$$= 1.013 \times 10^{-29} \times \left(3.00 \times 10^8\right)^2$$

$$= 9.12 \times 10^{-13} \text{ J}$$ (1 mark)

Part 2: Binding Energy

(e)   Binding energy/nucleon is a measure of the energy required to release (or bind) a nucleon.
                                      (1 mark)
      The bigger the binding energy is the more stable the nucleus.   (1 mark)
      The graph shows large mass numbers have smaller binding energy therefore are less stable.
                                      (1 mark)