MARKSCHEME

November 2002

PHYSICS

Higher Level

Paper 2

18 pages

Subject Details: Physics HL Paper 2 Markscheme

General

A markscheme often has more specific points worthy of a mark than the total allows. This is intentional. Do not award more than the maximum marks allowed for part of a question.

When deciding upon alternative answers by candidates to those given in the markscheme, consider the following points:

- Each marking point has a separate line and the end is signified by means of a semicolon (;).
- An alternative answer or wording is indicated in the markscheme by a "/"; either wording can be accepted.
- Words in (…) in the markscheme are not necessary to gain the mark.
- The order of points does not have to be as written (unless stated otherwise).
- If the candidate's answer has the same "meaning" or can be clearly interpreted as being the same as that in the mark scheme then award the mark.
- Mark positively. Give candidates credit for what they have achieved, and for what they have got correct, rather than penalising them for what they have not achieved or what they have got wrong.
- Remember that many candidates are writing in a second language. Effective communication is more important than grammatical accuracy.
- Occasionally, a part of a question may require a calculation whose answer is required for subsequent parts. If an error is made in the first part then it should be penalized. However, if the incorrect answer is used correctly in subsequent parts then **follow through** marks should be awarded. Indicate this with **"ECF"**, error carried forward.
- Units should always be given where appropriate. Omission of units should only be penalized once. Indicate this by **"U-1"** at the first point it occurs. Ignore this, if marks for units are already specified in the markscheme.
- Deduct **1 mark in the paper** for gross sig dig error *i.e.* for an **error of 2 or more digits**.

e.g. if the answer is 1.63:

2	*reject*
1.6	accept
1.63	accept
1.631	accept
1.6314	*reject*

Indicate the mark deduction by **"SD-1"**. However if a question specifically deals with uncertainties and significant digits, and marks for sig digs are already specified in the markscheme, then do <u>not</u> deduct again.

SECTION A

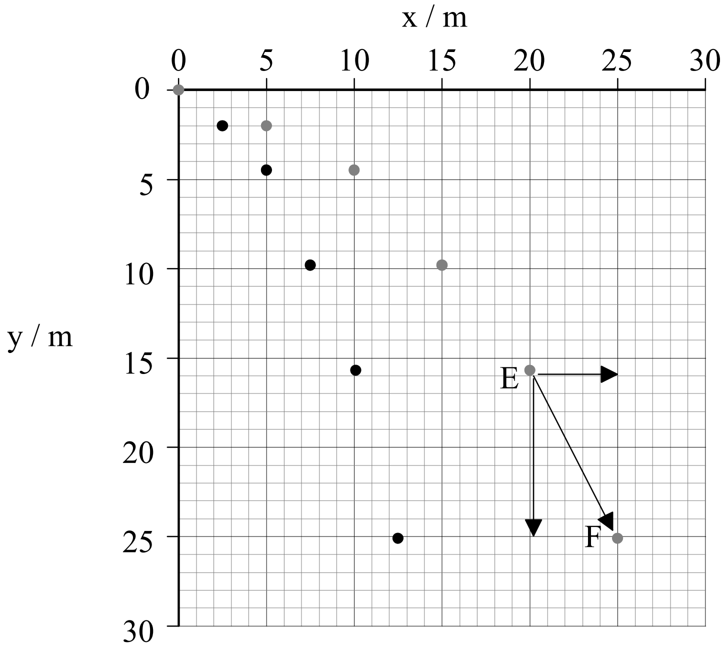
A1. Projectile motion on a planet

(a) horizontal: projectile moves 5 m in 0.5 s;
so $v = \frac{5}{0.5} = 10\ \text{m s}^{-1}$; ***[2 max]***

(b) horizontal distance travelled between images is always the same;
so no significant atmosphere, since air resistance would otherwise slow the horizontal motion; ***[2 max]***

(c) different planet mass than Earth;
and different radius than Earth; ***[2 max]***

(d) displacement vector;
horizontal component vector;
vertical component vector; ***[3 max]***



(e) vertical: 9 m in 0.5 s;
$v = 18\ \text{m s}^{-1}$; ***[2 max]***

(f) half previous horizontal spacing;
same vertical positions at each time interval; ***[2 max]***

A2. Portable radio power supply

(a) need 8 V drop across R to get 12 V across radio;
$R = \frac{V}{I}$;
$= \frac{8}{0.4} = 20\ \Omega$; ***[3 max]***

(b) $P = VI = 8 \times 0.4 = 3.2\ \text{W}$;
choose 5 W resistor since it can handle 3.2 W / *OWTTE*;
10 W is overkill / *OWTTE*; ***[2 max]***

(c) overheat / burn out / cause damage / *OWTTE*; ***[1]***

(d) if voltage across R_1 is 12 V, then
will be 20 – 12 = 8 V across R_2;
if R_1 and R_2 are low, radio resistance
has insignificant effect on divider circuit;
and
thus $\frac{R_1}{R_2} = \frac{12}{8} = \frac{3}{2}$; ***[3 max]***

A3. X-Ray spectra

(a) *Look for these ideas:*
in bremsstrahlung (continuous spectrum)
when **all** the electron energy goes into producing one X-ray photon;
it produces maximum photon energy;
i.e. minimum photon wavelength; ***[3 max]***

(b) from the graph $\lambda_{\min} = 5\times10^{-11}$ m ;

$$Ve = \frac{hc}{\lambda_{\min}} \;;$$

$$V = \frac{hc}{e\lambda_{\min}} = \frac{6.6\times10^{-34}\times3\times10^{8}}{1.6\times10^{-19}\times5\times10^{-11}} \;;$$

= 25 kV; ***[4 max]***

(c) (i) at lower voltages the energy of electrons (25 keV) is not sufficient to knock out the innermost electrons from the W atom;
so no characteristic x-rays produced by de excitation;
OWTTE; ***[2 max]***

(ii) smaller $\lambda_{\min}$;
new peaks at smaller λ; ***[2 max]***

(iii) the difference in energy between the K-shell and L-shell in W is greater than that for Mo;
so electron transitions between these levels will give rise photons of higher energy (lower λ); ***[2 max]***

i.e. Look for a simple explanation in terms of energy levels that show they understand the mechanism of the production of characteristic spectra

SECTION B

B1. Part 1 Thermodynamics of two-stage gas process

(a) sketch rough hyperbola section;
going to double volume and half pressure; ***[2 max]***

(b) molecules have further to go before striking a wall;
so collide with walls less frequently, resulting in lower pressure;
OR
there are fewer molecules per unit volume;
so fewer collisions per unit time with walls; ***[2 max]***

(c) (i) work is done **by** the gas;
the piston is pushed out by pressure of gas, through a distance;
OWTTE; ***[2 max]***

(ii) internal does not change, since temperature remains constant; ***[1]***
*Answer without reason **[0]**.*

(iii) gas does work so loses energy;
so to maintain constant temperature thermal energy flows **in**;
OWTTE; ***[2 max]***

(d) thermal energy transfer and work done are equal;
since internal energy (temperature) of the gas is unchanged after the process; ***[2 max]***

(e) straight line from origin through and beyond state 2;
to twice the pressure and twice the absolute temperature; ***[2 max]***

(f) *Look for at least three of the four aspects listed below.*
heat increases kinetic energy of molecules;
molecules moving faster, so strike walls more often;
and with higher velocity;
both aspects lead to bigger rate of momentum change at wall; ***[3 max]***

(g) (i) no work is done;
since the volume does not change; ***[2 max]***

(ii) yes since the gas is heated and no work is done; ***[1]***

(h) initial temperature is $20\,^{\circ}\mathrm{C}$ or 293 K;
stays the same after first process
second process $PV = nRT$, so $T \propto P$ at constant V;
so T doubles to 586 K or $313\,^{\circ}\mathrm{C}$;
or they might use $\frac{P_1}{T_1} = \frac{P_2}{T_2}$; ***[3 max]***

B1. Part 2 Pendulum collision

(a) (i) $\frac{1}{2} m_1 v_1^{\ 2} = mgh_1$;
$v = \sqrt{2gh_1}$; ***[2 max]***

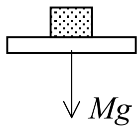
(ii) $p_{\text{before}} = m_1\sqrt{2gh_1}$;
$p_{\text{after}} = (m_1 + m_2)v^{/}$;
$p_{\text{before}} = p_{\text{after}}$;
to give $v^{/} = \dfrac{m_1\sqrt{2gh_1}}{m_1 + m_2}$; ***[4 max]***

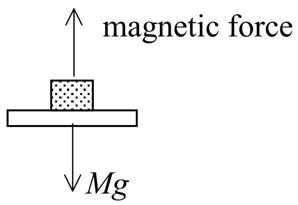
(b) conservation of energy; ***[1]***

(c) because the collisions between the balls is inelastic / energy is always lost in the collision between the balls / *OWTTE*;
larger mass ascending; ***[1]***

B2. Part 1 An electric generator

(a) (i) (ii)





(i) only downward force due to load;
(ii) downward force;
plus upward magnetic force; ***[3 max]***

(b) accelerates initially since only force of gravity acts on it;
but as current is generated in the rod, magnetic force arises due to current-carrying rod moving across magnetic field;
this is opposite to motion, so equilibrium will occur when magnetic force is equal to weight, and constant (terminal) speed results; ***[3 max]***

(c) in equilibrium: weight = magnetic force;
$Mg = BIL$;
$I = \frac{Mg}{BL}$; ***[3 max]***

(d) (i) $\Delta\phi = BL\Delta y$; ***[1]***

(ii) $E = \frac{\Delta\phi}{\Delta t} = \frac{BL\Delta y}{\Delta t}$;
$= BLv$; ***[2 max]***

(e) $R = \frac{E}{I}$;
$= \frac{BLv_T}{Mg / BL}$;
$= \frac{B^2L^2v_T}{Mg}$;
to give $v_T = \frac{MgR}{B^2L^2}$; ***[4 max]***

(f) non-continuous operation: rod would reach the bottom and then have to be returned to its original height to start again; ***[1]***

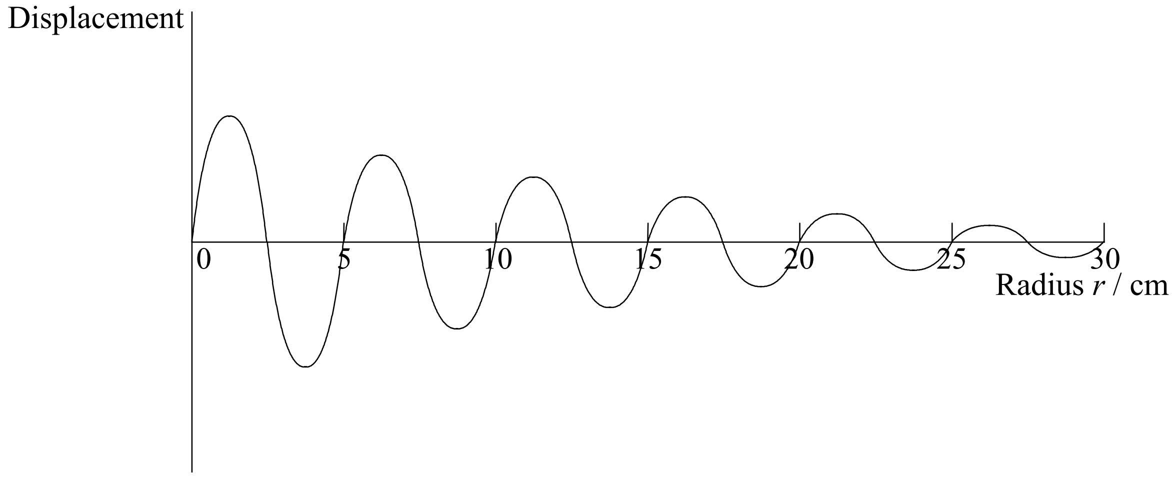
B2. Part 2 Properties of circular waves on water

(a) motion of the particles is perpendicular;
to direction of wave travel / *OWTTE*;
or by suitable diagram; ***[2 max]***

(b) (i) 5 cm in $\frac{1}{3}$ second;
so $v = 15\,\text{cm}\,\text{s}^{-1}$; ***[2 max]***

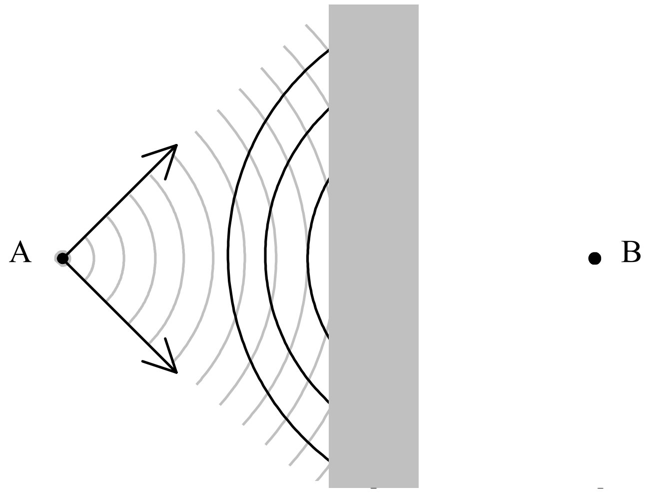
(ii) amplitude will decrease;
because wavefront circumference is increasing so energy is more "spread out"; *OWTTE*; ***[2 max]***
*Allow **[1]** for saying energy dissipates with time or distance due to frictional effects.*

(iii)



oscillations;
correct wavelength (5.0 cm);
decreasing amplitude; ***[3 max]***

(c)



(i) correct wavefront; ***[1]***

(ii) two rays at right angles to the wavefronts originating from A; ***[1]***

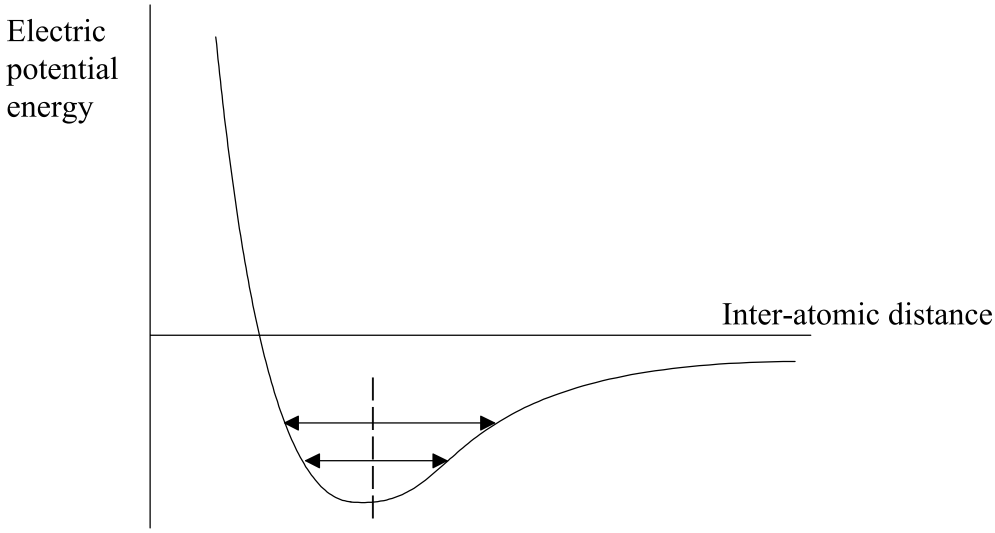
(iii) reflected rays;
extended backwards to intersect at B; ***[2 max]***
B should be roughly as far behind the left hand side of the barrier as A is in front.

B3. Part 1 Iron bridge

(a) due to thermal expansion;
the bridge roadway could buckle; ***[2 max]***

(b) total length expanding: $3 \times 25 = 75$ m;
change $\Delta T = 60\,^{\circ}\mathrm{C}$;
$\Delta L = L_0 \propto \Delta T$;
$= 75 \times 1.3 \times 10^{-5} \times 60 = 5.85 \times 10^{-2}\ \mathrm{m} = 5.85\,\mathrm{cm}$;
0.98 cm gap at each end
1.95 cm gap at each end of section 2; ***[5 max]***

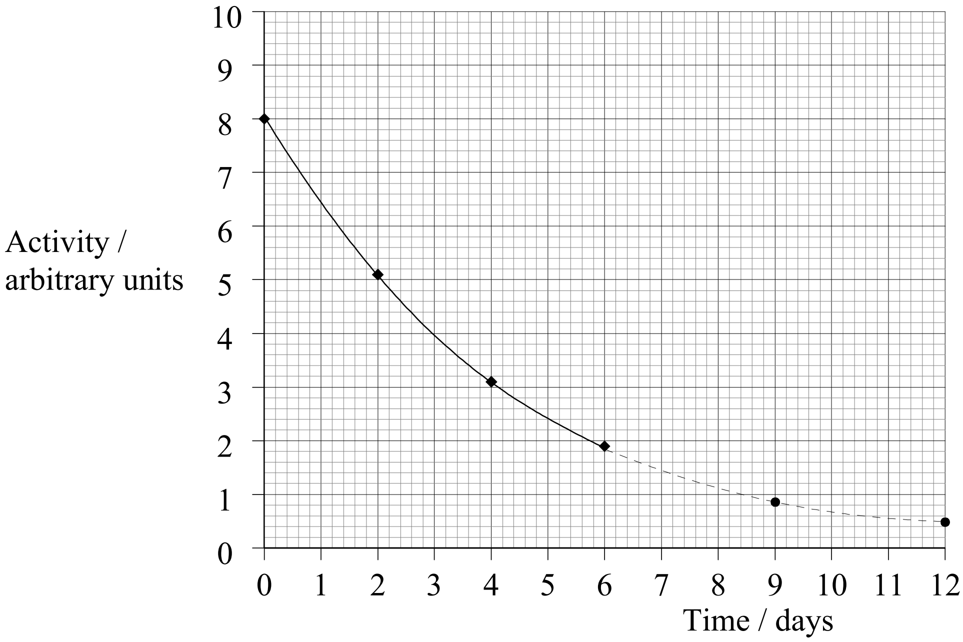
(c)



Mark by overall judgement and look for these main ideas:
thermal vibration means atom vibrates back and forth in the well as shown;
there will be an average interatomic separation as shown;
at a higher temperature, it will vibrate with greater amplitude;
the average separation will be slightly larger, because the potential well is asymmetric;
hence the sample expands slightly; ***[5 max]***

B3. Part 2 Radioactive decay

(a)



best fit smooth curve; ***[1]***

(b) (i) after 5 days, activity is about 2.4 units; ***[1]***

(ii) half-life is 3 days;
when activity drops from 8 to 4 units; ***[2 max]***

(c) general shape;
precise shape (*i.e.* activity at 9 days is 1); ***[2 max]***

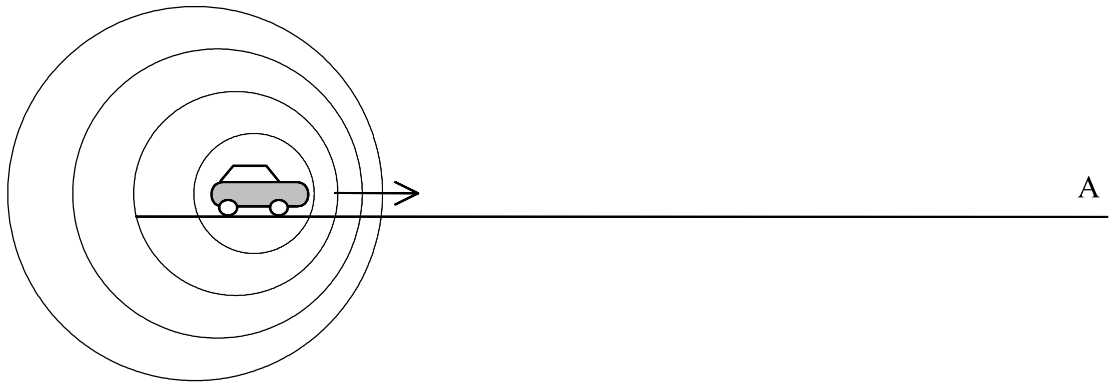
B3. Part 3 The Doppler effect

(a) (i) $\text{distance} = \dfrac{\text{speed}}{\text{frequency}}$;

$= \dfrac{330}{440} = \dfrac{3}{4\,\text{m}} = 0.75\,\text{m}$; ***[2 max]***

(ii) frequency = 440 Hz; ***[1]***

(b) (i)



wavefronts circular;
but centred on points successively further to the right;
so spaced closer to right, further apart to left; ***[3 max]***

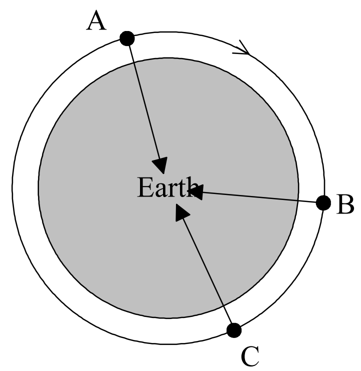
(ii) progressing at $330\,\text{ms}^{-1}$; ***[1]***

(c) (i) distance was 0.75 m when car was at rest. Now, in one period, *i.e.* 1/440 s, second wavefront will be (8) / (440) = 0.018 m closer to the first;
so distance between wavefronts is 0.75 – 0.018 = 0.732 m; ***[3 max]***

(ii) no of wavefronts/per second is speed/distance between wavefronts $= \dfrac{330}{0.732} = 451\,\text{s}^{-1}$;
will hear frequency of 451 Hz; ***[2 max]***

B4. Part 1 Satellite orbits

(a)



vectors all towards the centre;
all the same length; ***[2 max]***

(b) *Look for an argument along the following lines*:
a few hundred km is small compared to radius of the Earth;
g depends on $\dfrac{1}{R^2}$;
so a small change in R will not produce a significant change in g;
OWTTE ***[3 max]***

(c) $mg = \dfrac{mv^2}{R_E}$;
$v^2 = gR_E$;
$T = \dfrac{2\pi R_E}{v}$;
so $T = \dfrac{2\pi R_E}{\sqrt{gR_E}}$;
substitute $T = \dfrac{2 \times 3.14 \times 6.4 \times 10^6}{\sqrt{10 \times 6.4 \times 10^6}}$;
$\approx 5000\text{s} \approx 84$ min ; ***[6 max]***

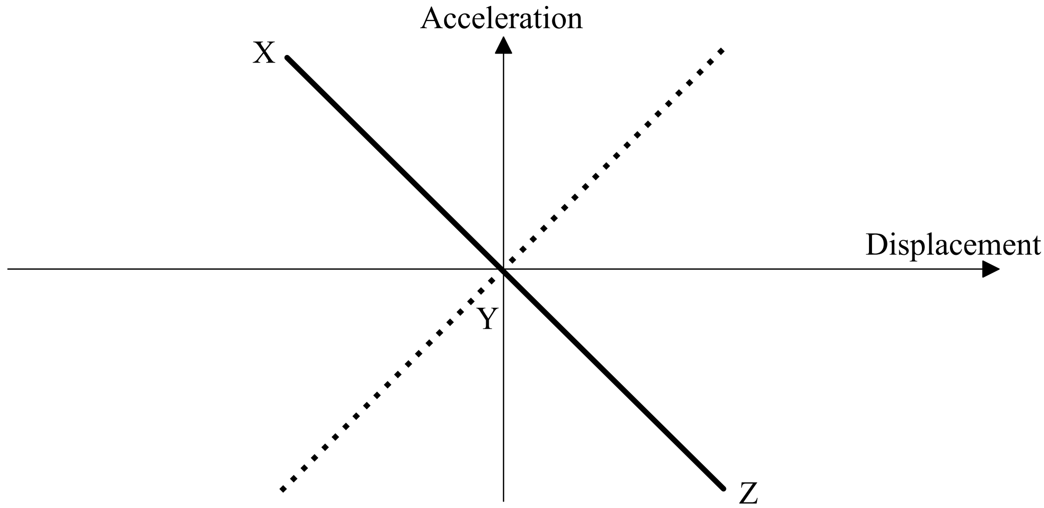
(d) $\dfrac{mv^2}{R} = \dfrac{GMm}{R^2}$;
to give $v^2 = \dfrac{GM}{R}$;
and $T = \dfrac{2\pi R}{v}$;
therefore $T^2 = \dfrac{4\pi^2 R^2}{v^2} = \dfrac{4\pi^2 R^3}{GM}$;
such that $\dfrac{R^3}{T^2} = \dfrac{GM}{4\pi^2} = \text{constant}$; ***[5 max]***

(e) orbital period of geostationary satellite = 24 × 60 = 1440 min;
using $\dfrac{R^3}{T^2} =$ constant we have $\dfrac{{R_E}^3}{84^2} = \dfrac{(nR_E)^3}{1440^2}$;
to give n ≈ 7;
or $R_{\text{SAT}} \approx 7R_E$; ***[3 max]***

B4. Part 2 Oscillations of an object suspended from a spring

(a) the (net) force (acceleration) on the object is proportional to the displacement of the object from equilibrium;
and is directed towards equilibrium; ***[2 max]***

(b)

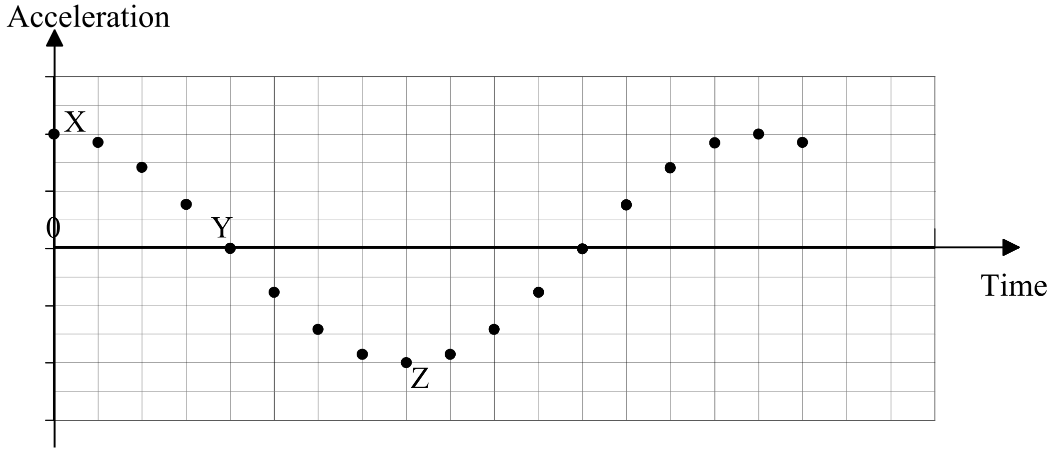


labelled axes;
correct line, only one quadrant shown;
dotted line;

[3 max]

(c) correct positions of X, Y and Z; ***[1]***

(d)



*If a sine, –cosine or – sine graph, award **[1]**.*
cosine graph;
correctly sketched over one time period; ***[2 max]***

(e) correct positions of X, Y and Z; ***[1]***

(f) $F_{\max} = -kx_{\max} = ma_{\max}$;

$a_{\max} = \dfrac{kx_{\max}}{m} = 2.0 \times \dfrac{0.12}{0.05} = 4.8\,\text{m s}^{-2}$ *(accept ±)*; ***[2 max]***