physics 2006 TEE

PHYSICS 2006 MARKING GUIDE

SECTION A: Short Answers **(60 Marks)**

1.

Beats	Diffraction	
Example:	Example:	[2 marks]
Conditions: Two waves with similar frequencies interact.	Conditions: Wave fronts passing a barrier or through a gap with width similar to wavelength.	[2 marks]

2.

For lowest frequency: $L = n\lambda / 2$ where $n = 1$
$\lambda = 2 \times 3 = 6$ m [2 marks]

$f = \dfrac{v}{\lambda} = \dfrac{346}{6} = 58$ Hz (or 60 Hz) [2 marks]

(closed pipe: max 3 marks if done correctly.)
(no working = zero)

3. Q is best [1 mark]
...because there is a greater torque for same applied force (diagram)
Torque is proportional to the radius of the handle (not length), $\tau = r \times F$ [3 marks]

4. Water exerts pressure (hence a force) on the dam wall.
The dam wall in A is under compression. The dam wall in B is under tension. [2 marks]
Brick/concrete has high compressive strength, but a low tensile strength, which may result in cracks (weakening the whole structure—leading to collapse) [2 marks]

5.

$\theta = \tan^{-1}(6/0.5) = 85.2°$ (or compliment 4.76°) [1 mark]

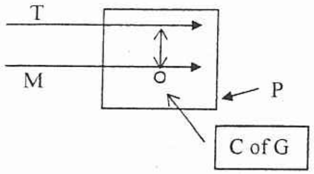
$F = 2\,T \cos\theta$ [2 marks]

$T = \dfrac{800}{2\cos 85.2} = 4.82 \times 10^3\ N$ = 4800N [1 mark]

6. Answer = A [1 mark]

Explanation can be verbal and/or mathematical
g at any point depends on the square of the distance from that point to the centre of the earth
(g is proportional to $1/r^2$). [1 mark]
The height of Mt Everest (about 9000m) is very much less than the radius of the earth. The two distances are about 6409000 m and 6400000 m, and so g will be not very different from what it is at the earth's surface. ($g_{\text{Everest}} = 99.7\%\ g_{\text{sea level}}$) [2 marks]

7.



T acts further from the pivot point ,P, than does M. [1 mark]

T will tend to produce a larger torque (causing the chair to rotate about its leg) as it is further from the pivot. [2 marks]

Whereas M will provide enough force to overcome friction but not enough torque to counter the torque from C of G. [1 marks]

8. The earth rotates once in 24 hours, so a complete 360° star trail will represent 24 hours (15° represents 1 hour). [2 marks]
Any of the arcs shown cover approximately 25°-27°, which represent a time of about 100-108 minutes. Hence shutter was open about 100-110 minutes. [2 marks]
Since only an estimate may use values from **20° to 30°** to give times of **80 to 120** minutes

9 a) $P_{in} = P_{out}$
so $V_1I_1 = V_2I_2$ hence as voltage is changed, current must also be changed. [2 marks]

9 b) $P_{out} = 0.90 \times P_{in}$
$50 = 0.90\,(240)\,I_{in}$
Hence $I_{in} = 0.23$ A. [2 marks]

10 a) $F = mg = 1.25 \times 10^3 \times 9.8 = 1.22 \times 10^4$ N [1 mark]

10 b) $F = mg - \dfrac{mv^2}{r} = 1.25\times10^3(9.8) - \dfrac{1.25\times10^3(20)^2}{80} = 6.00\times10^3\ N$ [3 marks]

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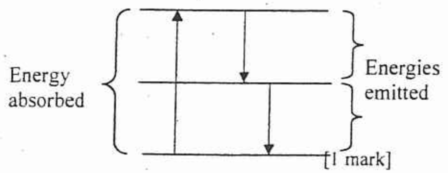


Wavelength is longer [1 mark]

Energy of emitted photons is less than energy of absorbed photon. [1 mark]

Since $v = f\lambda$ and $E = hf$
If E is less, f is less and λ is larger (i.e. wavelength is longer). [1 mark]

12 Area $= \pi r^2 = \pi(1\times10^{-3})^2 = 3.14\times10^{-6}$ m^2 $\quad l = 30\times10^{-2}$ m [1 mark]

$$Y = \frac{F/A}{l/\Delta l}$$

$$\Delta l = \frac{Fl}{YA} = \frac{250(30\times10^{-2})}{(5.04\times10^9)(3.14\times10^{-6})} = 4.74\times10^{-3}\ \text{m}$$ [3 marks]

1(ci) $v_{ts} = 1.68 \sin\alpha - 0.014$

Suggest Graphical method: 4 marks for sin α (in table) and graph.
Graphics calculator: 4 marks for sin α and line of best fit/regression line. [4 marks]

1(cii) gradient = 1.68 cm s^{-1} or 0.0168 m s^{-1} [2 marks]

1(d) $v_{ts} = \left(\dfrac{mgR}{l^2B^2}\right)\sin\alpha$ hence gradient $= \dfrac{mgR}{l^2B^2}$ [2 mark]

$$0.0168 = \frac{mgR}{l^2B^2}$$

$$B = \sqrt{\frac{mgR}{l^2(0.0168)}} = \sqrt{\frac{(44\times10^{-3})(9.8)(1.4\times10^{-4})}{(0.20)^2(0.0168)}} = 0.30\ \text{T}$$ [2 marks]

Students who use 1.68 should get 0.030 T

Students who use 1.57 should get 0.031 T

Question 2	**[20 marks]**

2(ai) Diagram should show an oscillating bubble and formation of spherical pressure waves (rarefactions and compressions) [para 2] [3 marks]

2(aii)

$$f_0 = \frac{1}{2\pi}\sqrt{\frac{3\gamma P_0}{\rho {R_0}^2}}$$ [1 mark]

$$= \frac{1}{2\pi}\sqrt{\frac{3(1.4)(100\times10^3)}{(1\times10^3)(3\times10^{-3})^2}}$$

$$= 1088$$ [3 marks]

$$\approx 1100\ \text{Hz}$$

2(bi) $f = \dfrac{300}{60} = 5$ Hz $\quad v = 14$ ms^{-1} [1 mark]

$v = \dfrac{2\pi r}{T} = 2\pi r f$

$r = \dfrac{v}{2\pi f} = \dfrac{14}{2\pi(5)} = 0.45$ m i.e. 0.45 m along blade from centre. [3 marks]

2(bii) The tips of the blades or where water speed (relative to blade) is greatest [2 marks]

2(ci) From the figure 1: radius ≈ 3.5 mm [2 marks]
2(cii) From either figure: time ≈ 0.3 ms [2 marks]
2(ciii) Figure 2 shows a high-pressure pulse, over 50kPa change in pressure, produced during the time that the bubble collapses. This small shock wave/pressure pulse can stun small creatures. [3 marks]

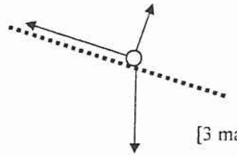
SECTION C: Comprehension and Interpretation (40 Marks)

Question 1 [20 marks]

1(ai) Weight (mg) or gravitational force exerted by Earth

Force acting up and parallel to plane—as a result of induced current moving through magnetic field

Reaction force exerted by rails (normal reaction)



[3 marks]

1(aii) Force up the plane increases with speed of the rod down the plane.
When this force equals the component of weight acting down the plane, it travels at constant velocity [2 marks]

1(b) Weight $W = mg$ Induced emf $V = lvB$

Force on current $F = ILB$ $V = IR$ [2 marks]

At constant velocity: $F_{mag} = F_{g\ parallel}$

$$F = mg\sin\alpha$$

$$IlB = mg\sin\alpha$$

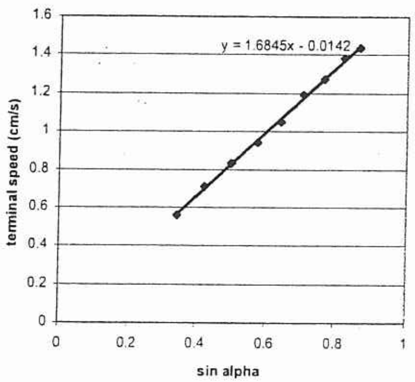
$$\left(\frac{V}{R}\right)lB = mg\sin\alpha$$ [3 marks]

$$\left(\frac{lvB}{R}\right)lB = mg\sin\alpha$$

$$v_{ts} = \frac{(mg\sin\alpha)R}{l^2B^2}$$

1(c)

Angle (α)	Terminal speed (cm/s)	sin α
20	0.56	0.34
25	0.71	0.42
30	0.83	0.50
35	0.94	0.57
40	1.05	0.64
45	1.19	0.71
50	1.27	0.77
55	1.38	0.82
60	1.44	0.87



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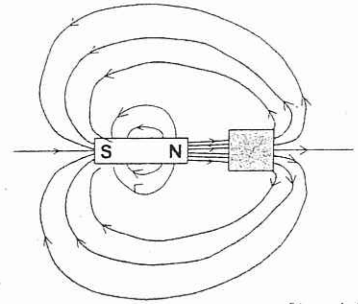
(2) soft iron becomes magnet
(flux concentrated through iron)

(2) overall shape - near field + large scale field

field lines touching subtract one mark



[4 marks]

14 Answer A [1 mark]
Electric field is towards the right so force on electrons due to electric field is to the left. [1 mark]
Magnetic field is to the right, so force on moving charge due to magnetic filed is upwards.
(right hand palm rule) [2 marks]
The resultant force will direct the beam towards quadrant A.

15 Answer A [1 mark]
The force that prevents the car hitting the wall will be the force (or component of it) that acts perpendicularly away from the wall.

For situation (a), this force is provided by braking the car. (1)

For situation (b), this force is provided by centripetal force only (or more correctly, the component of this force acting perpendicularly away from the wall). Initially, this component is zero, but is increases to the full centripetal force when the car is parallel to the wall. (1)

Hence, the centripetal force needed for situation (b) would have to be much greater than the braking force for situation (a) for it to have an equal effect in preventing the car from hitting the barrier. (1)

OR **Calculation** might involve using:

(a) loss KE = $F_b.s$ $F_b = m v^2 / 2s$ (1)

(b) $F_f = m v^2 / s$ (1)

Thus $F_b = F_f / 2$ This suggests that the braking force need only be half the centripetal force. [3 marks]
(1)

SECTION B: Problem Solving (100 Marks)

Question 1	[10 marks]

1(a) High pitch is a high frequency sound [1 mark]
Ultrasonic means that the pitch is so high that it can't be heard by humans [1 mark]

1(b) $v = \lambda f$ $346 = \lambda(18 \times 10^3)$ [2 marks]
$\lambda = 0.019$ m (1.9 cm) [1 mark]

1(c) $P = E \times t$ Assume area = $2\pi r^2$ a hemisphere
but may use sphere $4\pi r^2$ (1 mark only)

$$Intensity\ at\ 3m = \frac{P}{A} = \frac{5}{2\pi 3^2} = 8.84 x 10^{-2}\ Wm^{-2}$$

$$2\ 'mosquitos' = 0.177\ Wm^{-2}$$ [4 marks]

$$dB = 10 \log \frac{0.177}{10^{-12}} = 112 dB$$

(109dB for a sphere) [2 marks]

Question 2	[13 marks]

2(a) 4500 rpm = 4500/60 Hz = 75 Hz r = 0.10 m [2 marks]

$$v = \frac{s}{t} = \frac{2\pi r}{t} = 2\pi(0.10)75 = 47.1\ ms^{-1}$$ [2 marks]

2(b) $$a = \frac{v^2}{r} = \frac{(47.1)^2}{0.1} = 2.22 \times 10^4\ ms^{-2}$$ [3 marks]

2(c)
$F_{max} = 8$ mN $= 8 \times 10^{-3}$ N m = 89 ng = 89×10^{-9} g = 89×10^{-12} kg [2 marks]

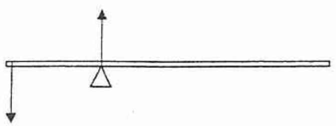
$$g = \frac{F}{m} = \frac{8 \times 10^{-3}}{89 \times 10^{-12}} = 8.99 \times 10^7\ ms^{-2}$$ [1 marks]

$$v = \sqrt{rg} = \sqrt{0.1(8.99 \times 10^7)} = 3000\ ms^{-1}$$ [1 marks]

$$f = \frac{v}{2\pi r} = \frac{3000}{2\pi(0.1)} = 4.77 \times 10^3\ Hz = 2.86 x 10^5\ rpm$$ [2 marks]

Question 3	[16 marks]

3(a)



[2 marks]

7(cii) Best angle = 60° Best velocity = 30 ms^{-1} [2 marks]
Explanation may include any of the following:
Maximum height should be around 35m
Launch speed = 20 ms^{-1} won't reach required height
Launch speed = 30 ms^{-1} but angles ≤ 50° and ≥ 60° won't reach required height
Launch speed = 40 ms^{-1} at angle of 70-80° is possible but reaches too great a height
[2 marks]

Question 7	[15 marks]

7(a) $v_H = 40\cos 60^o$ $v_V = 40\sin 60^o$ [Students may use $h = \dfrac{v_0^{\,2}\sin^2\theta}{2g}$]

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

$s = h = \dfrac{v^2 - u^2}{2g} = \dfrac{0-(40\sin 60^o)^2}{2\times(-9.8)} = 61.2m$ (max *height above nozzle*) [2 marks]

$v = u + at$

$\therefore t = \dfrac{v-u}{g} = \dfrac{0-40\sin 60^o}{-9.8} = 3.53s$ [Students may use $R = \dfrac{v_0\sin 2\theta}{g}$]

$v = \dfrac{s}{t}$

$s = R = v_H t = 40\cos 60^o \times 2\times 3.53 = 141m$ (*range*)

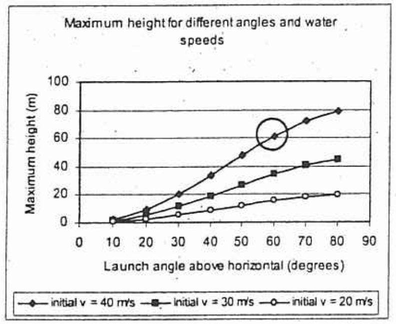
Assume height of nozzle negligible [2 marks]

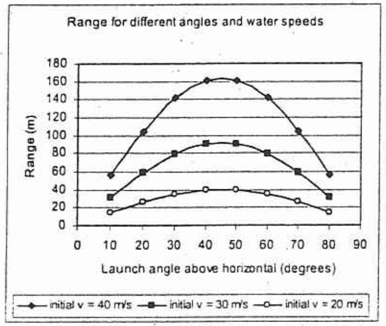
7(b) $s_H = 150m$ $v_H = 22\ ms^{-1}$

Horizontal: $v = \dfrac{s}{t}$ hence $t = \dfrac{s_H}{v_H} = \dfrac{150}{22} = 6.82s$ [2 marks]

Vertical: $s = ut + \frac{1}{2}at^2 = 0 + \frac{1}{2}(9.8)(6.82)^2 = 228m$ (= minimum height) [3 marks]

7(ci)





[2 marks]

3(b)

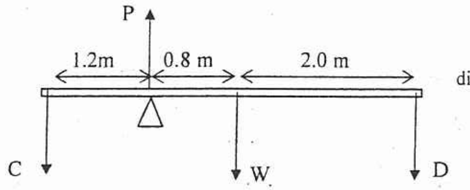


diagram with correct distances [1 mark]

Board is in equilibrium therefore Σ CWM = Σ ACWM

Taking moments about P:

W (0.8) + D (2.8) = C (1.2)

(120) (9.8) (0.8) + (62.5) (9.8) (2.8) = (C (1.2)

C = 2.21 x10^4 N [3 marks]

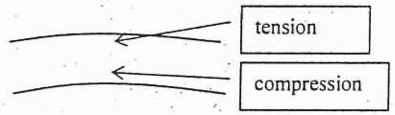
$\Sigma F_{up} = \Sigma F_{down}$

P = C + W + D

= 2.21 x10^4 + (120 (9.8) + 62.5 (9.8)

= 4.00 x10^3 N [2 marks]

3(ci)



[1 mark]

[1 mark]

3(cii) When standing, the force acting on the end of the board equals the weight of the diver [1 mark]

When the falling diver lands on the end of the board, the board must exert extra force to decelerate the diver to rest (W = Fs). This force is related to the restoring force in the deformed board.

The board is deformed as it absorbs the KE of the falling diver. The KE is converted to PE in the board. [2 marks]

3(ciii) Factors that might be considered include:

- Breaking stress of material (should be high enough so board does not break)
- Young's Modulus—not too high (board won't bend enough) nor too small (boards will bend too much).
- Density of board (would affect the overall weight and hence force on P and C)

[3 marks]

Question 4	[17 marks]

4(ai) torque = 2r (I l B) N = 2 NIAB hence size of motor (radius and length of armature) or area, current (I), magnetic field strength (B), number of turns (N) [2 marks]

4(aii) only current (I) [1 mark]

4(b) Answer B Answer C [2 marks]

4(c) Power output = 0.68 x 200 x10^3 W = 136 x10^3 W [1 mark]

$$p = \frac{KE\ gained}{t} = \frac{mv^2}{2t} = 544\ kJ$$ 1

$$v_{max} = \sqrt{\frac{2Pt}{m}} = \sqrt{\frac{2(136\times10^3)4}{4.4\times10^3}} = 15.7\ ms^{-1}$$

1 1 [3 marks]

4(di) Without regenerative braking, all of the KE of the bus is lost to heat each time it brakes. The heat is dissipated. With regenerative braking, at least some of this KE is re-captured in the form of chemical (potential) energy and is then available for later re-conversion to KE. [2 marks]

4(dii) Rapid/emergency braking might be required. **(low speeds insufficient force)** [1 mark]

4(e) Three assumptions are needed—number of turns (N), shape of armature (r) and diameter of wheel. 60 km/h = 16.7 ms^{-1} Estimate N = 100 turns, rectangular coil length 0.8m and d_{wheel} = 1m [1 mark]

frequency of motor = frequency of wheel since there is no gearing.

$$v = \frac{2\pi r}{t} = 2\pi rf \quad \therefore f = \frac{v}{2\pi r} = \frac{16.7}{2\pi 0.5} = 5.3Hz$$ [2 marks]

V_{max} = 2NBlv = 2πBANf = 2πx2.0x0.7x0.8x100x5.3 = 3.7kV [2 marks]

(This is far too high as it cannot exceed the applied voltage: the field given is unusually high and the motor dimensions are very big)

or Quarter turn method: (This only gives an approximate average and therefore is not a maximum)

$$t = \frac{T}{4} = \frac{s}{4v} = \frac{2\pi r}{4v} = \frac{2\pi(0.5)}{4(16.7)} = 0.047s$$ [2 marks]

$$V_{avg} = \frac{-N\Delta\Phi}{\Delta t} = \frac{NBA}{t} = \frac{100(2.0)(0.7x0.8)}{0.047} = 2.4\ kV$$ [2 marks]

Question 5 [12 marks]

5(ai) properties = frequency and intensity (or sufficient **energy** and small enough **wavelength** to be able to penetrate tissues without being absorbed) [2 marks]

5(aii) Yes, they are very high energy and have a small enough wavelength to penetrate the body [1 mark]

5(bi) $E = hf = \frac{hc}{\lambda}$ 1 [1 mark]

$$\lambda = \frac{hc}{E} = \frac{(6.63\times10^{-34})(3\times10^8)}{32(1.6\times10^{-19})} = 3.89\times10^{-8}m \approx 4\times10^{-8}m = 40nm$$ 1 1 [2 marks]

5(bii) ultraviolet 1 [1 mark]

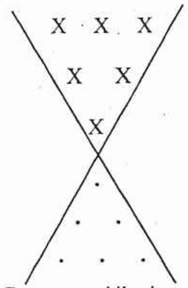
5(ci) Electrons only absorb energy when they are promoted to a higher energy state. Therefore they will only absorb photon energy that is equivalent to the difference between energy states (levels). Since photon energies are quantised only those of specific energy will be absorbed. [2 marks]

5(cii) The energy appears as KE of the ejected electron (and eventually dissipated as heat in tissues). [1 mark]

5(ciii) Unlikely as microwaves can't cause ionisation of atoms in the tissues—energy per photon is too low. [2 marks]

Question 6 [16 marks]

6(ai)



Dots at the bottom, crosses at the top [2 marks]

Equally spaced [1 mark]

6(aii) Forces act while electron moves in field
Force is perpendicular to the velocity causing it to move in arc in plane of paper
The longer the distance in the field, the more curve (displacement from original path), and therefore outer electrons deviate more than those nearer the middle. [3 marks]

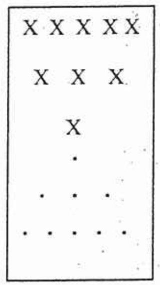
6(b)

F = qvB

$$B = \frac{F}{qv}$$ [2 mark]

$$= \frac{4.59\times10^{-4}}{(1.6\times10^{-19})(2.05\times10^6)} = 0.14\ T$$ [2 marks]

6(c)



Dots at the bottom, crosses at the top [1 mark]

Fields stronger at the outer parts [2 marks]

6(d) Contexts

Sunlight & starlight e.g. Formation of auroras as charged particle enter the earth's magnetic field	Medical applications e.g. Cyclotrons CRTs using magnetic fields	Domestic/industrial applications e.g. CRTs using magnetic fields Mass spectrometer	[1 marks]
(brief description)	(brief description)	(brief description)	[2 mark]