$$F = \frac{GmM_{Io}}{R_{Io}^2} = mg_{Io}$$ [1]

$$g_{Io} = \frac{GM_{Io}}{R_{Io}^2}$$ [1]

$$g_{Io} = \frac{6.67\times10^{-11}\times8.94\times10^{22}}{1.82\times10^{6}}$$ [1]

$= 1.80\ ms^{-2}$ (directed towards the centre of Io) [1]

(b) [3 marks]

$$F = \frac{GmM_J}{(r-R_{Io})^2} = mg_{J,inner}$$

$$g_{J,inner} = \frac{GM_J}{(r-R_{Io})^2}$$ [2]

$$g_{J,inner} = \frac{6.67\times10^{-11}\times1.90\times10^{27}}{(4.22\times10^{8}-1.82\times10^{6})^2}$$ [1]

$= 0.718\ ms^{-2}$ (directed towards Jupiter) [1]

(c) [2 marks]

$g_{inner} = 1.80 - 0.718 = 1.08\ ms^{-2}$ (towards centre of Io) [2]

(d) [3 marks]

The cause is related to the relative position of the moons Europa and Ganymede to Io, and the differing effects that their gravitational fields (magnitude and direction) have on Io. [1]

This has the effect of increasing the Δg by varying amounts over time (shown in graph). [2]

Note that the stress on Io due to Jupiter is constant and does not cause its 'tides'.

(e) [4 marks]

$R_{Io} = 1.82 \times 10^6$ m,

g (from graph) = $(12 \times 10^{-5} - 1.5 \times 10^{-5}) = 10.5 \times 10^{-5}\ ms^{-2}$ (could accept 12×10^{-5})

$g_o = (1.08 + 2.51) \div 2 = 1.8\ ms^{-2}$ from part (c) and extra information

$$h \approx \frac{\Delta g}{g_o} R_{Io}$$ [1]

$$h \approx \frac{10.5\times10^{-5}}{1.8} 1.82\times10^{6}$$ [2]

= 110 m (if use 12×10^{-5} height is 120 m) [1]

(f) [4 marks]

Answer: diagram 2 [4]

Curriculum Council
Government of Western Australia

WACE

Tertiary Entrance Examination, 2007

PHYSICS

Marking Guidelines

SECTION C: Comprehension and Interpretation (40 Marks)

Question 1 [20 marks]

(a) [3 marks]

$$\text{constant} = \left(\frac{\pi^2\ W\ T^3}{12}\right)$$

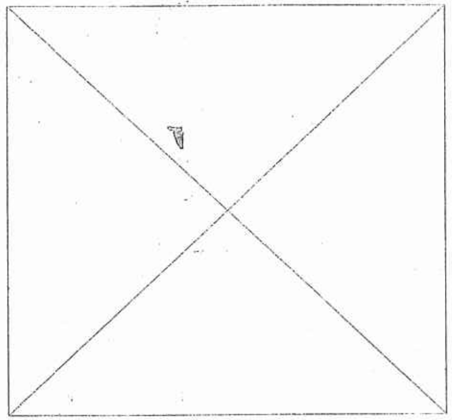
$$= \left(\frac{\pi^2\ (0.0286)\ (0.004)^3}{12}\right) \qquad [2]$$

$= 1.51 \times 10^{-9}\ m^4$ [1]

(b) [5 marks]

$1 / L^2$
1.00
1.18
1.49
1.98
2.60
3.84
6.25

Table [1]



Graph: axes [1]
labels [1]
line [2]

(c) [3 marks]

Gradient $= 95\text{N} \div 6.25\text{m}^{-2}$ [2]

$= 15.2\ \text{N m}^2$ [1]

(d) [4 marks]

$$F_b = \frac{(1.51 \times 10^{-9})Y}{1} \times \frac{1}{L^2}$$

$$Y = \frac{F_b \times L^2}{(1.51 \times 10^{-9})} \qquad [2]$$

$= 1.0 \times 10^{10}\ \text{Pa}$ [2]

(e) [2 marks]

The wood is possibly Maple – this has the Young's modulus closest to the value determined from the graph.
It may also not be one of the woods mentioned as the error is approx 10%

(f) [3 marks]

It isn't correct because an elastic material is one that undergoes no permanent deformation when an applied force is removed [3]

Question 2 [20 marks]

(a) [4 marks]

(c) [4 marks]

Since $r = \frac{mv}{qB}$ and velocity of a circular orbit is given by $v = \frac{2\pi r}{T}$ [1]

Then $v = \frac{rqB}{m} = \frac{2\pi r}{T}$ [1]

$\therefore T = \frac{2\pi m}{qB}$ [1]

which is independent of r [1]

7. [14 marks]

(a) [3 marks]

Any 2 from:

Goldfish have maximum hearing sensitivity at a much lower frequency than dolphins. [2]

GF have a higher hearing threshold at their most sensitive frequency [1]

GF cannot hear frequencies above about 2 kHz whereas dolphins can hear to well over 100 kHz

(b) [5 marks]

(i)

$\lambda = c \div f$

[1]

$= 1530 \div 50 \times 10^3 = 0.0306$m

[2]

(ii) A shad: approx 135-140 dB [1]

A dolphin: approx 40 dB [1]

(c) [6 marks]

S

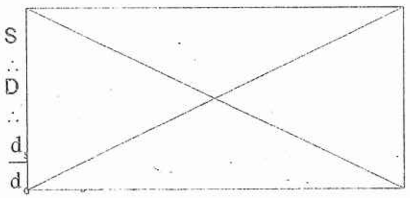
∴

D

∴

d

d



had: $140 = 10 \log (I_s \div 10^{-12})$

I_s (minimum) = 100 W m^{-2} [1]

olphin: $40 = 10 \log (I_d \div 10^{-12})$

I_d (minimum) = 1×10^{-8} W m^{-2} [1]

[2]

$$d_d = \sqrt{\frac{d_s{}^2 I_s(\min)}{I_d(\min)}}$$

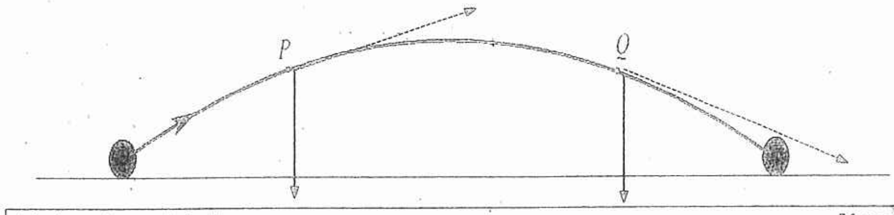
$$\therefore = \sqrt{\frac{10^2 \times 100}{1 \times 10^{-8}}}$$

$= 1 \times 10^6$ m ~ 100 km. [2]

(for 135 dB, d = 560 km)

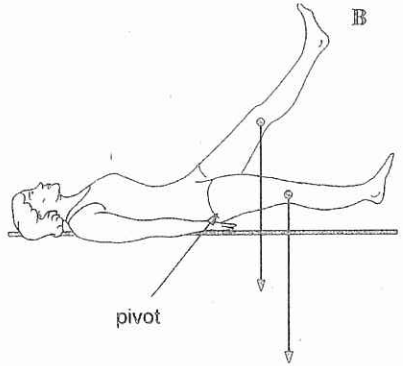
SECTION A: Short Answers (60 Marks)

1.



(a) 1 mark per dotted arrow [4 marks]
(b) 1 mark per solid arrow

2.

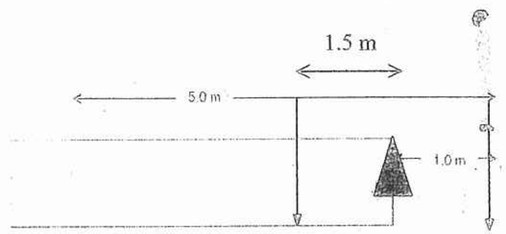


At (A) the torque (or CWM) provided by weight of leg is greater than at (B) due to greater horizontal distance from pivot (hip). [3 marks]

Hence tension in muscle to provide balancing torque will be greater in (A) than in (B). [1 mark]

Must refer to/use diagram for full marks

3.



Estimate mass of boy = 70 ± 40 kg [1 mark]

Taking moments about the end of the wall [1 mark]

$W_{plank} \times 1.5 = W_{boy} \times 1$ therefore $W_{plank} = 50 \times 9.8 \div 1.5 = 327$ N

Mass of plank = 327 ÷ 9.8 = 33 kg (Mass of plank = 2/3 Mass of boy) [2 marks]

4.

Radius of orbit = $(2.0 \times 10^7 + 6.37 \times 10^6)$ m = 2.64×10^7 m [1 mark]

T = (12 x 3600) s

= 4.32×10^4 s

v = 2 π R ÷ T
= 2 π (2.0 x 107 ÷ 6.37 x 106) ÷ (12 x 3600) = 3.84 x 103 ms-1 [3 marks]
Alternate: v = √ (GME ÷ R)
= 6.67 x10-11 x 5.98 x1024 ÷ (2.0 x 107 + 6.37 x 106) = 3.89 x 103 ms-1

5.

Vertical component of magnetic field = (2.70 10–5 T) sin 65
= 2.45 10–5 T. [1 mark]

$emf = lvB$ [1 mark]

$= (59.5\ m) \times 270\ \text{m s}^{-1} \times (2.45 \times 10^{-5}\ \text{T})$ [2 marks]

$= 0.393\ V.$

6.

B is correct [1 mark]
The compass needle is a magnet (arrow head is N-pole). [1 mark]
It will align with the field of the bar magnet—and point in the direction of the field lines (N to S) [2 marks]

7.

For 180°

Φ = BA [1 mark]
= $(1.2 \times 10^{-5})\ (0.30)^2$
ΔΦ = $2 \times (1.2 \times 10^{-5})\ (0.30)^2$ [3 marks]
= 2.16×10^{-6} Wb

8.

Wave with large time period:
Period = 1559 ms – 1549 ms = 10 ms [2 marks]
$f = T^{-1}$ ∴ frequency = 100 Hz.
Wave with smaller time period completes 10 whole oscillations in 10 ms, so frequency is 1000 Hz [2 marks]

9.

Wave nature	Particle nature
Adequate description of 1. double slit experiment OR 2. diffraction (wave fronts), OR 3. refraction (wave fronts), OR 4. polarization [2 marks]	Adequate description of 1. reflection (particles) OR 2. photoelectric effect (E = hν) 3. Compton scattering (momentum transfer) [2 marks]

10.

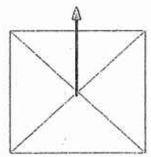
[ALT = 78 cm]

(c) [4 marks]
Wind will only affect horizontal velocity component
$v_H = 3.43 + 0.28 = 3.71\ \text{m s}^{-1}$ [1]
As vertical cpt of velocity is unchanged, t will still be 0.70 s
Therefore s = v t = 3.73 (0.7) = 2.6 m [2]
Since far edge of hole is 2.5 m away, the jet will not land in the hole. [1]

(d) [4 marks]
Working in vertical direction only, t = (v – u) / a
Hence t ∝ Δv
For A, Δv (vert) = 2 x 5.83 sin 60 = 10 m s^{-1}
For B, Δv (vert) = 2 x 4.85 sin 45 = 6.9 m s^{-1}
For C, Δv (vert) = 2 x 4.52 sin 30 = 4.5 m s^{-1}
Therefore if they leave at the same instant, C will land first, then B then A. [2]
Reasoning: [2]

6. [12 marks]

(a) [4 marks]
F = qvB [1]
= $(1.6 \times 10^{-19})\ (1.10 \times 10^{3})\ (0.200)$ [1]
= 3.52×10^{-20} N. [1]
Direction of force



[1]

(b) [4 marks]

$$B = \frac{mv}{qr}$$ [1]

$$B = \frac{1.67 \times 10^{-27} \times 10 \times 10^{3}}{1.6 \times 10^{-19} \times 0.015}$$ [2]

= 6.96×10^{-3} T [1]

The % transmission light of wavelength 377 nm falls in the above range (i.e. is ~60% transmission) so this cover would be suitable. [

2]

4. [14 marks]

(a) [3 marks]

$\lambda = 2 \times 1.45 = 2.90$ m [

1]

$f = \dfrac{c}{\lambda} = \dfrac{346}{2.90} = 119$ Hz [

2]

(b) [5 marks]

At 25° C and 0.0290 kg c = 346 m s^{-1}
At 37° C and 0.0296 kg

$$\text{speed} = 3.41 \times \sqrt{\frac{(273+37)}{0.0296}} = 349 \text{ ms}^{-1}$$ [

2]

$f = \dfrac{c}{2L}$ [

1]

$= \dfrac{349}{2 \times 1.45} = 120 \text{ Hz}$ [

2]

(c) [6 marks]

(i) $L = \dfrac{c}{2f} = \dfrac{349}{2 \times 88} = 1.98$ m [

2]

Extra length = 1.98 – 1.45 = 0.53 m [

1]

(ii) One half a metre is probably close to the distance from mouth to the lungs of a large person, so the candidate's proposition might be reasonable. [3]

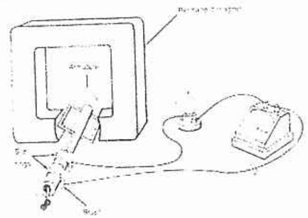
5. [16 marks]

(a) [4 marks]

$v_H = s \div t = 2.4 \div 0.70 = 3.43$ m s^{-1}	[2]
$v_H = v \cos 45$	[1]
$\therefore v = v_H \div \cos 45 = 4.85$ m s^{-1}	[1]

(b) [4 marks]

Using t = 0.35 s	[1]
S = ut + ½ a t^2	
= 4.85 sin 45 (0.35) + ½(9.8)(0.35)²	[2]
= 0.60 m (60 cm)	[1]



(a) Alternating current generator or AC dynamo [2 marks]

(b) Reasons
a. current is produced (lighted globe),
b. slip rings for alternating current
c. no power source
d. coil spinning between magnetic poles [2 marks]

11.

(a) The generated emf reverses because the change in flux producing the emf increases as it approaches the coil and decreases as the magnet passes through the coil. By Lenz's Law a current is produced to oppose the change in flux.	[2 marks]
(b) The emf generated is proportional to the rate of change of magnetic flux and this is proportional to the speed of the magnet. The magnet is accelerating due to gravity so the second peak is bigger.	[2 marks]

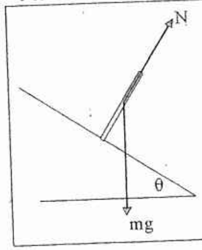
12.

Radius of loop = r, At top of loop: mg = $mv^2 \div r$ ∴ $v_{top} = \sqrt{(rg)} = 1.98$ ms^{-1}	[1 marks]
From conservation of energy $PE_A = KE_{top\ loop} + PE_{top\ loop}$ mgA = ½ mrg + mg2r	[2 marks]
∴ A = ½ r + 2r If r = 0.4 m, A = 1.0 m.	[1 mark]

13.

130 W = 130 J s^{-1}	[1 mark]
85% efficiency means power output is 0.85 x 130 = 110.5 J s^{-1}	
E_{photon} = h c ÷ λ = (6.63 x 10^{-34}) (3 x10^8) ÷ (5.90 x10^{-9})	[2 marks]
= 3.37 x 10^{-19} J.	[1 mark]
Photons per second = 110.5 ÷ 3.37 x 10^{-19} = 3.28 x 10^{20}	

14.

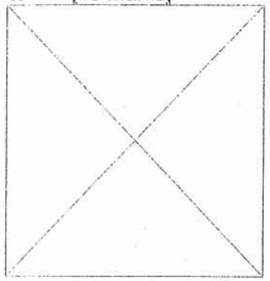
	Derive equation from diagram: Vertically: N cos θ = mg Horizontally: N sin θ = mv^2 ÷ r	[2 marks]
	∴ tan = v^2÷ rg = (15.5)² ÷ (35 x 9.8)	[1 mark]
	= 0.7	[1 mark]
	so angle of bank = 35°	

15.

When the motor is turning at full speed, an emf is induced in the opposite direction to the applied current (Lenz's Law). The motor therefore draws a relatively small current.	[2 marks]
The jammed piece of wood stops the motor turning, there is little or no 'back' emf hence a larger current than normal flows.	[2 marks]

SECTION B: Problem Solving (100 Marks)

1. [13 marks]



(a) [3 marks]
Forces acting downwards = weight of swing + weight of baby
[1]
= 3 kg + 3.6 kg = 6.6 kg
= 64.7 N
[1]
Therefore the tension in one arm is 32.3 N
[1]
[3 marks]

(b) [3 marks]
v = s ÷ t
= 0.90 ÷1.6 = 0.563 ms^{-1} [1]
a = v^2 ÷ r = $(0.563)^2$ ÷ 0.60
= 0.527 ms^{-2}
[2]

(c) [3marks]
Total force = mg + mv^2 ÷ r
[1]
= 6.6 (9.8) + 6.6 $(0.563)^2$ ÷ 0.6
= 68.2 N
[1]
Tension in each arm = 34.1 N
[1]

(d) [4 marks]

$$stress = \frac{F}{A} = \frac{mg + mv^2/r}{\pi r^2}$$

[1]

$$stress = \frac{(15+3)/2 * (9.8+0.53)}{\pi(7.5x10^{-3})^2} = 5.26x10^5\ N\,m^{-2}$$

[2]
This is less than the breaking stress of PVC so the swing is unlikely to break.
[1]

2. [16 marks]

(a) [2 marks]
Ground or earth line for safety reasons
[2]

(b) [3 marks]
P = V I

$$I = \frac{P}{V} = \frac{346 \times 10^3}{240}$$

[2]
= 1.44 x 10^3 A
[1]

(c) [4 marks]

$$R = \frac{543}{10} \times 1.74x10^{-5} = 9.45 \text{ x } 10^{-4}$$

$$P = I^2R = \left(1.44 \times 10^3\right)^2\ 9.45 \times 10^{-4}$$

[2]
= 1.96 x10^3 W
Total power loss = 2* 1.96 x10^3 W = 3.93 x10^3 W
[1]

(d) [4 marks]
Diagram or description should indicate laminated iron transformer core with one turn on the secondary (240 V output) for every 275 turn on the primary (66 kV input)
[4]

Working: $\frac{V_s}{V_p} = \frac{N_s}{N_p}$ so $\frac{N_s}{N_p} = \frac{240}{66x10^3} = 0.00363 = \frac{1}{275}$

(e) [3 marks]
Power is transmitted at higher voltage because this means lower current (P = V I).
[2]
Power loss as heat generated in the wires is given by I^2R so it is minimised if the current is lower. [1]

3. [15 marks]

(a) [4 marks]
Largest wavelength: ΔE = -0.55– (-3.85) = 3.30 eV [2]
(= 3.30 x 1.6 x10^{-19} = 5.28 x10^{-19} J)
E = hc ÷ λ
λ = hc ÷ E
[1]
= (6.63 x10^{-34})(3 x 10^8) ÷ 5.28 x10^{-19} = 3.77 x 10^{-7} m
[1]

(b) [5 marks]
Req/d line corresponds to transition from level 2 to 1
[1]
ΔE = -2.05– (-3.85) = 1.80 eV
[2]
(= 1.80 x 1.6 x10^{-19} J = 2.88 x10^{-19} J)
E = hc ÷ λ
λ = hc ÷ E = (6.63 x10^{-34})(3 x 10^8) / 2.88 x10^{-19} = 6.91 x 10^{-7} m
[1]
This corresponds to red—so stony coral is **red** under UV light
[1]

(c) [6 marks]
(i) UV radiation has high energy and low wavelength so can cause ionisation of atoms/molecules and penetrate tissues.
[2]
If this occurs in DNA (cell nuclei) in sufficient amounts, cell replication is affected leading to skin cancer (or permanently damaged cells)
[1]
May give other specific examples
(ii) UV light with wavelengths in the range 375-400nm have greater than 50% transmission
[1]