YEAR 12 PHYSICS
MID YEAR EXAMINATION 2008

SOLUTIONS

A		
B		
C		
Total		/ 188 = %

TIME ALLOWED FOR THIS PAPER.

Reading Time 10.0 minutes
Working Time 3.00 hours

MATERIALS REQUIRED.

Pens, pencils, correction fluid, ruler, and a calculator satisfying the conditions set by the Curriculum Council of Western Australia.

INSTRUCTIONS TO CANDIDATES.

This exam consists of three sections. The formula and physical constants are provided separately.

SECTION A: Short Answer Section:

This section contains thirteen [13] questions of **equal value** and is worth 28%

[52 marks]

SECTION B: Longer Questions and Problems

This contains seven [7] questions, which are **not of equal value** and is worth 56%

[106 marks]

SECTION C: Comprehension and Interpretation Section:

This section contains one [1] question and is worth 16%.

[30 marks]

Write your answers in the space provided in full and give numerical values to three significant figures [unless otherwise indicated].

Marks will be awarded for clear working even if an incorrect answer is obtained. Marks will be deducted for absent or incorrect units.

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SECTION A

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1. A horizontal conductor in a power line carries a current of 5000 A from south to north. The Earth's magnetic field at the location of the conductor has a magnitude of 60.0 μT and is inclined upward at 70° to the horizontal. Find the force on 100 m of the conductor.

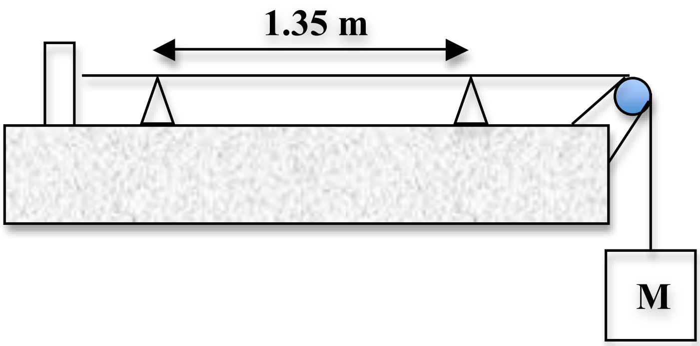
[4]

I = 5000 A
B = 60.0 μT
l = 100 m

$F = IlB$ (1)
$= (5000)(100)(60.0 \times 10^{-6})(\sin 70°)$ (1)
$= 28.2$ N (1)

East (1)

2. A wire is stretched over bridges A and B as shown in the diagram below. When the wire is plucked a student observes **2** places on the wire (not including the bridges) where the wire does not appear to move at all and detects a frequency of 430 Hz.



(a) Determine the speed of the wave on the wire.

[3]

$L = \frac{3\lambda}{2}$

$\lambda = \frac{(2)(1.35)}{3} = 0.90$ m (1)

f = 430 Hz

$\lambda = 0.90$ m
$v = f\lambda$ (1)
$= (0.90)(430)$
$= 387$ ms^{-1} (1)

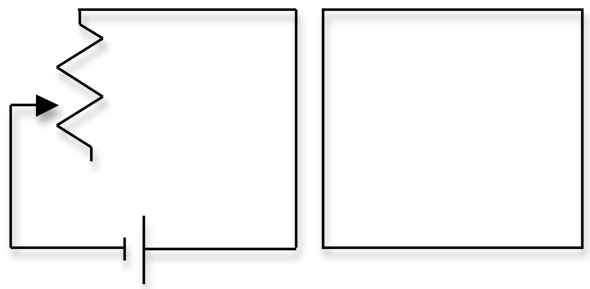
(b) If the student is trying to tune the wire to a 440 Hz tuning fork, would he need to increase or decrease the number of weights hanging from the wire?

[1]

- Increase

3. If the resistance of the variable resistor R in the left hand circuit in the diagram below is slowly **increased**, is the current induced in the right hand loop clockwise or counter clockwise? Explain your reasoning.

[4]



- As resistance increases, the current in the circuit will decrease.
- The ACW current will have a magnetic field out of the page associated with it inside the loop – but a magnetic field into the page outside the loop (and therefore extending through the second loop).
- Thus according to Lenz's Law, an emf will be induced in the second coil to oppose this change (ie to induce a magnetic field going into the page).
  So the current will be **clockwise.**

4. What is the power output for a 60.0 kg woman who runs up a 3.00 m high flight of stairs in 2.50 s? The woman starts from rest but has a final speed of 2.00 ms^{-1}.

[4]

h = 3.00 m
m = 60.0 kg
t = 2.50 s
v = 2.00 ms^{-1}

$$P = \frac{W}{t} \text{ (1)} = \frac{\Delta E}{t} = \frac{E_{Kf} + E_{Pf}}{t} \text{ (1)}$$

$$= \frac{(0.5)(60)(2^2) + (60)(9.8)(3)}{2.50} \text{ (1)}$$

$$= 754 \text{ W (1)}$$

5. String instruments such as guitars and violins have a hollow wooden box (known as a sound box) as part of their construction. Explain why this is so.

[4]

- The string is too narrow to push effectively on the air and so the volume of air disturbed by the string is so small that no sound can be heard.
- The string transfers mechanical energy through the bridge to the body of the instrument.
- The sound box vibrates and disturbs a much greater volume of air.
- resonance may also occur in the sound box which will further amplify the sound level.

6. A uniform magnetic field **B**, of magnitude 1.20 mT, points vertically upwards throughout a scattering chamber. A proton with velocity 3.16 x 10^7 ms^{-1} enters the chamber, moving horizontally from north to south. Determine the force that acts on the proton as it enters the chamber.

[4]

$B = 1.20 \times 10^{-3}$ T
$q = 1.6 \times 10^{-19}$ C
$v = 3.16 \times 10^{7}$ ms^{-1}
F = ?

$F = qvB$ (1)
$= (1.6 \times 10^{-19})(3.16 \times 10^{7})(1.20 \times 10^{-3})$ (1)
$= 6.07 \times 10^{-15}$ N (1)

West (1)

7. The soft furnishings of concert halls, such as the carpet on the floor, the fabric on chairs and the velvet curtains, are often thought to be just decorative by members of the public. Explain the function and need for such furnishings in a concert hall and their effect on reverberation time.

[4]

- Hard surfaces are very good at reflecting sound waves.
- If there is a lot of reflection, sound waves that come directly from the stage can interfere with echoes of previous sounds which arrive later and cause a muffling of the sound.
- Soft furnishings such as carpets, chairs and curtains are much more effective at absorbing sound waves thus decreasing echoes in the room.
- Reduces reverberation time (the time for a sound level intensity to drop by 60dB) – this time will be prolonged if there are significant echoes.

8. The wheels of a midsize car exert a force of 2100 N backwards on the road.

(a) If the wheels are exerting backwards force on the road, how is the car able to move forward?

[2]

- Newton's 3rd Law states that for every action there is an equal and opposite reaction (action and reaction forces are on different objects).
- The wheels of the car exert a backwards force on the road therefore the road exerts a forwards force on the car – accelerating it in the forwards direction.

If the force of friction including air resistance is 250 N and the acceleration of the car is 1.80 ms^{-2}.

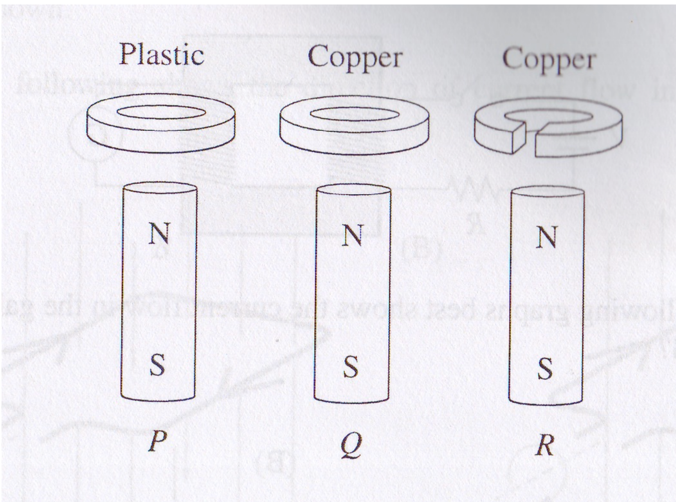
(b) Determine the mass of the car plus its occupants.

[2]

$F_f = 250$ N
$a = 1.80\ ms^{-2}$
$m = ?$
$F_d = 2100$ N

$\Sigma F_x = F_d - F_f = ma$ (1)
$\Rightarrow 2100 - 250 = (m)(1.80)$
$m = 1.03 \times 10^3$ kg (1)

9. Three rings are dropped at the same time over identical magnets as shown below.



Which of the following best describes the order in which the rings P, Q and R reach the bottom of the magnets.

(a) They arrive in the order P, Q, R

(b) They arrive in the order P, R, Q

(c) Rings P and R arrive simultaneously, followed by Q.

(d) Rings Q and R arrive simultaneously, followed by P.

Your answer: C

[1]

Explain your choice:

[3]

- As the rings drop over the magnets, there will be a changing magnetic flux through the ring, therefore a current will be induced (if the ring is metal and in a closed loop).
- P is made from plastic, an insulator, therefore no current is induced.
- R is made from copper, but has a split, therefore no induced current can flow.
- In Q a current can flow – therefore a magnetic field opposing the change will be induced and a retarding force will act on the ring. Therefore it will slow down and reach the bottom last.

10. If you blow across the top of an empty coke bottle, it emits a tone. Will adding water increase or decrease the frequency of this tone? Explain your reasoning.

[4]

- Increase
- The length of the column of air in the bottle will decrease
- Therefore the length of the resonant wavelengths will decrease.
- As the speed of sound in air is constant the frequency must increase.

11. A closely wound rectangular coil of 80 turns has dimensions of 25.0 cm x 40.0 cm. The plane of the coil is rotated in 0.06 s from a position where it makes an angle of 45° with a magnetic field of 1.10 T to a position perpendicular to the field. What is the EMF induced in the coil?

[4]

N = 80
A = (0.25)(0.40) = 0.1 m^2
Δt = 0.06 s
B = 1.10 T

$$\varepsilon = -\frac{\Delta\phi}{\Delta t}$$ (1)

$$\varepsilon = -\frac{(BA\cos 45 - BA\cos 0)}{\Delta t}$$ (1)

$$\varepsilon = -\frac{((1.10)(0.1)(\cos 45) - (1.10)(0.1))}{0.06}$$ (1)

$\varepsilon = (80)(5.37 \text{ x } 10^{-1}$ V) (1)

12. The wave motion (also known as simple harmonic motion) of a spring can be characterised by the formula;

$$T = 2\pi\sqrt{\frac{m}{k}}$$

where: T is the period of oscillation
m is the mass on the spring
k is the spring constant

A car can be considered to be mounted on four identical springs as far as vertical oscillations are concerned. If the springs of a certain car are adjusted so that the vibrations have a natural frequency of 3.00 Hz. Determine the spring constant of each spring if the mass of the car is 1450 kg and the weight is evenly distributed over the springs.

[4]

m = 1450 kg
f = 3.00 Hz
k = ?

$$T = \frac{1}{f} = \frac{1}{3} = 0.33$$ (1)

$$T = 2\pi\sqrt{\frac{m}{k}}$$

$$0.33 = 2\pi\sqrt{\frac{1450}{k}}$$ (1)

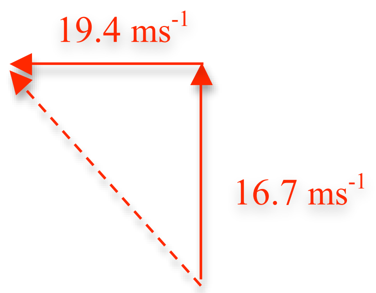
k = /4 5.26 x 10^5 kgs^{-2} (or Nm^{-1})

(1) (1)

13. A car initially moving in an easterly direction at 70.0 kmh^{-1} turns a corner and continues to travel at 60.0 kmh^{-1} in a northerly direction. Determine the change in velocity of the car in ms^{-1}.

[4]

u = 70 kmh^{-1} = 19.4 ms^{-1} East
v = 60 km h^{-1} = 16.7 ms^{-1} North



Δv = v – u
$= \sqrt{(16.7)^2 + (19.4)^2}$ (1)
= 25.6 ms^{-1}

$\tan\theta = \frac{19.4}{16.7}$ (1)
θ = 49.3 °

Δv = 25.6 ms^{-1} N 49.3°W

(1) (1)

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SECTION B

Name:____

1. One of the lathes in the D & T Workshop produces a sound level intensity of 36.0 dB when running.

(a) What is the intensity of the sound produced?

[3]

dB = 10 Log I/Io (1)

36 = 10 Log I / 10^{-12}
$10^{3.6}$ = I / 10^{-12} (1)

I = 3.98 x 10^{3} x 1 x 10^{-12}

= 3.98 x 10^{-9} Wm^{-2} (1)

(b) If the sound passes through an open door, of height 2.00 m and width 1.00 m, how much energy per second passes through?

[3]

Intensity = P /A (1)

= 3.98 x 10^{-9} x 2.0 x 1.0 (1)

= 7.96 x 10^{-9} J s^{-1} (1)

(c) If five **more** identical machines now also start up what is the combined sound level?

[4]

Intensity of one machine = 3.98 x 10^{-9} W m^{-2}

Five more machines makes six in total = 2.38 x 10^{-8} W m^{-2} (1)

ΔdB = 10 Log I_2 / I_1 (1)

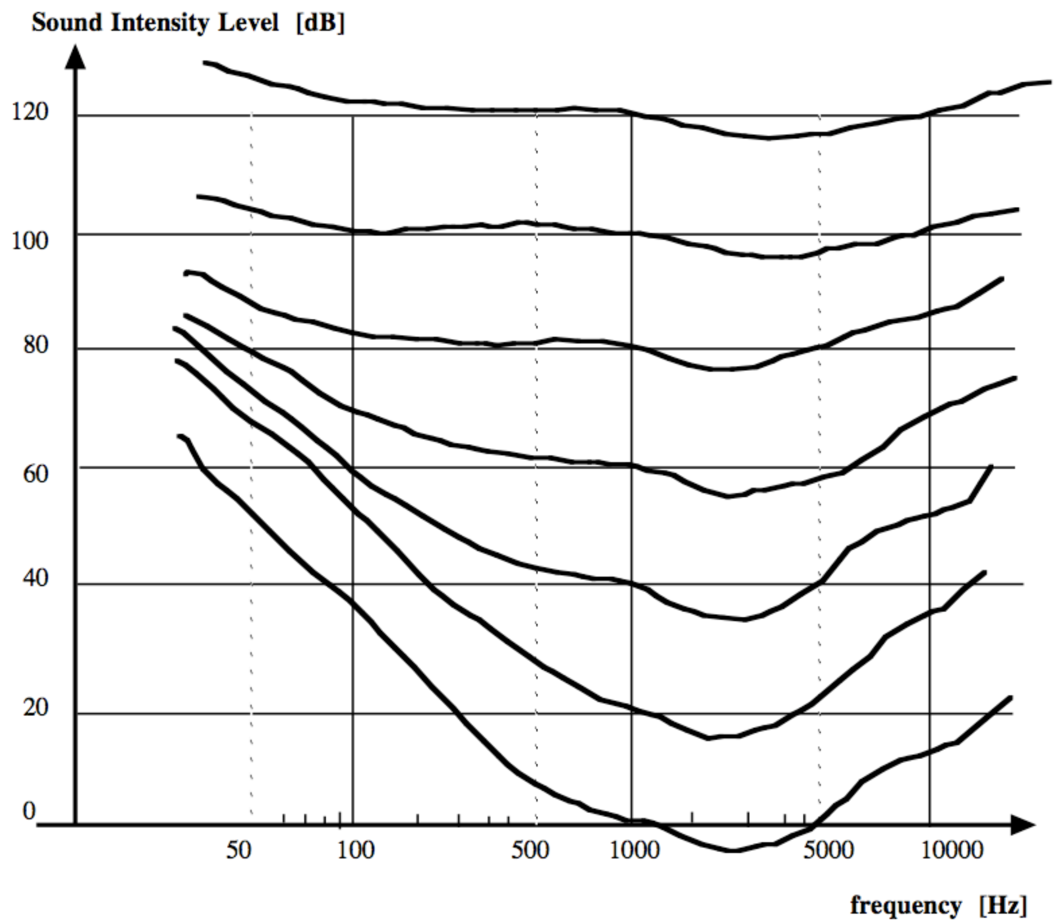
= 2.38 x 10^{-8} / 3.98 x 10^{-9}

= 7.76 (1)

new level is 36 + 7.76

= 43.7 dB (1)

The following diagram may be useful in answering parts (d) and (e).



(d) If the machines in the D & T workshop were producing noise at 1000 Hz, what would be the perceived intensity if the machines instead produced noise at 100 Hz?

[1]

From phon curve

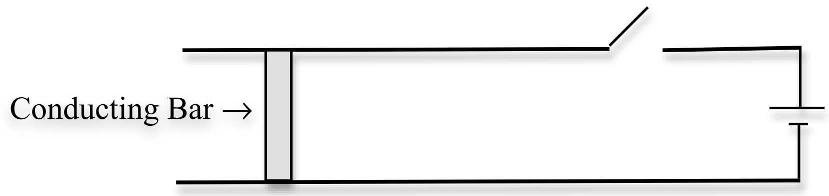
acceptable range 0 -10 phon

(e) Explain the difference, if any, in the sound intensity level.

[2]

- Your ear is not as sensitive to all frequencies,
- hence you percieve some sounds louder than others.

2. A conducting bar of mass 10.0 kg and length 50.0 cm slides over horizontal rails that are connected to a voltage source (as shown in the diagram below). The voltage source maintains a constant current of 20.0 A in the rails and bar when the switch S is closed. A constant, uniform, vertical magnetic field (directed out of the page) of 0.70 T fills the region between the rail. This setup is known as an electromagnetic rail gun.



(a) In which direction will the conducting bar move when the switch is closed?

[1]

- To the left

(b) Determine the magnitude of the force on the conducting bar when the switch is closed.

[2]

l = 0.50 m
I = 20.0 A
B = 0.70 T

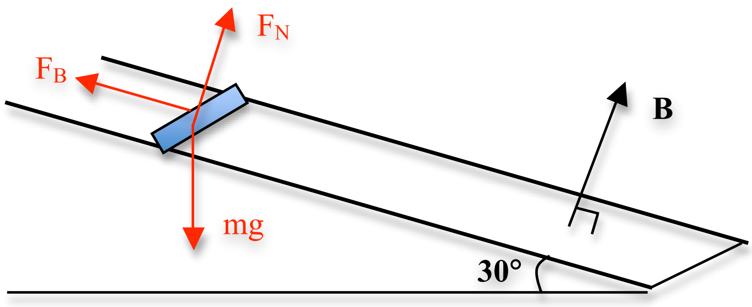
F = IlB (1)
= (20)(0.5)(0.70)
= 7.00 N (1)

(c) Will the current in the bar stay at a constant value? Explain your answer.

[4]

- No
- As the bar moves to the left, the amount of magnetic flux enclosed by the loop will increase. A changing magnetic flux (wrt time) means an emf will be induced in the loop (Faraday's Law).
- According to Lenz's Law the direction of this emf will be in such as direction as to oppose this change.
- The induced emf will be in the opposite direction to the applied emf so the net current will decrease.

The horizontal rails are now inclined at an angle of 30° to the horizontal as shown in the diagram below. The magnetic field is maintained so that it is perpendicular to the plane and a current continues to flows through the rails. Assume there is no friction between the rails and conducting bar.



(d) Indicate and label on the diagram above any forces acting on the conducting bar.

[3]

- mg (0.5 label, 0.5 arrow)
- F_N
- F_B

(e) What current must be passed through the conducting bar if it is not to slide down the incline? [Ignore any effects due to induced current in the bar and detail magnitude and direction (into the page or out of the page)].

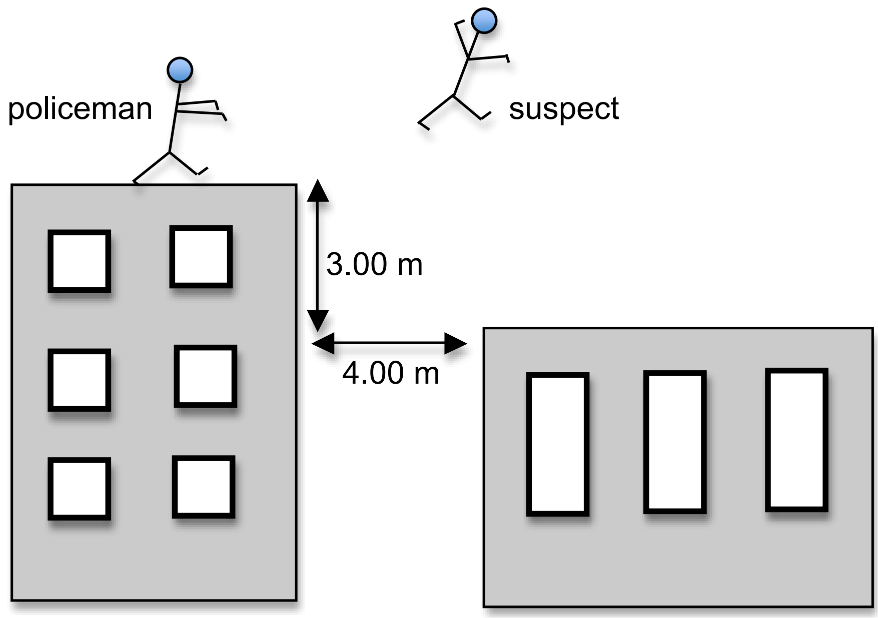
[5]

l = 0.50 m
B = 0.70 T
m = 10.0 kg

$F_B = mg\sin\theta$ (2)
$IlB = mg\sin\theta$
$(I)(0.5)(0.70) = (10)(9.8)(\sin 30°)$ (1)
$I = 140$ A (1)

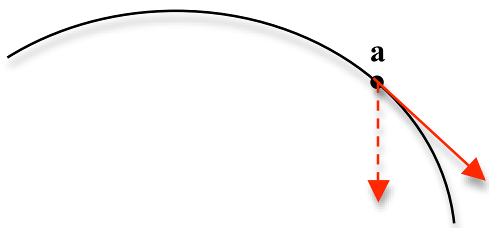
to the left (1)

3. On an American police drama, a policeman is chasing a suspect across the rooftops of buildings (as shown in the diagram below). Both are running at 5.00 ms^{-1} when they come to a gap between buildings that is 4.00 m wide and has a drop of 3.00 m. The suspect leaps at 5.00 ms^{-1} at an angle of 40° (above the horizontal) and clears the gap easily. The policeman leaps horizontally at 5.00 ms^{-1}. (Assume there is no air resistance).



(a) Draw a **solid arrow** ⟶ to indicate the direction of velocity of the thief and a **dashed arrow** - - - -➤ to indicate the direction of acceleration vector for the thief at the point marked **a**.

[2]



(b) Determine the horizontal and vertical components of the suspect's velocity.

[2]

$v_h = (5.00)(\cos 40) = 3.83\ ms^{-1}$
$v_v = (5.00)(\sin 40) = 3.21\ ms^{-1}$

(c) Determine the time the suspect is in the air before he lands.

[3]

s_v = -3.00 m
v_v = -3.21 ms^{-1}
a = -9.80 ms^{-2}
t = ?

$$s_v = u_v t + \frac{1}{2}at^2$$ (1)

$$-3 = (3.21)(t) + \frac{1}{2}(-9.8)(t^2)$$ (1)

t = 1.18 s (1)

(d) By how much does the suspect clear the gap?

[3]

s_h = ?
v_h = 3.83 ms^{-1}
t =

$s_h = tv_h$ (1)
= (1.18)(3.83)
= 4.52 m (1)

4.52 - 4.00 = 0.52 m (1)

(e) Does the policeman clear the gap? Show working to support your answer.

[4]

v_h = 5.00 ms^{-1}
v_v = 0 ms^{-1}
a = -9.8 ms^{-2}
s_v = -3.00 m
s_h = ?

$$s_v = u_v t + \frac{1}{2}at^2$$ (0.5)

$$-3 = (0)(t) + \frac{1}{2}(-9.8)(t^2)$$

t = 0.78 s (1)

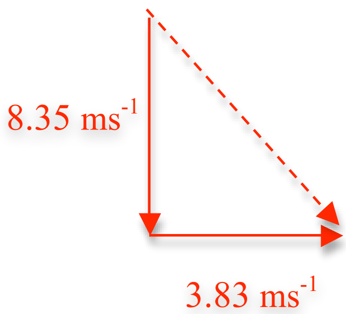
$s_h = v_h t$ (0.5)
= (5)(0.78)
= 3.91 m (1)

3.91 < 4.00 ∴ the policeman does not make the jump. (1)

(f) What will be the velocity of the suspect as he lands on the other side?

[5]

$u_h = v_h = 3.83\ ms^{-1}$
$u_v = 3.21\ ms^{-1}$
$v_v = ?$
$a = -9.8\ ms^{-2}$
$t = 1.18\ s$



$v_v = u_v + at$ (1)
$= 3.21 + (-9.8)(1.18)$
$= -8.35\ ms^{-1}$ (1)

$v = \sqrt{(8.35^2 + 3.83^2)}$ (0.5)

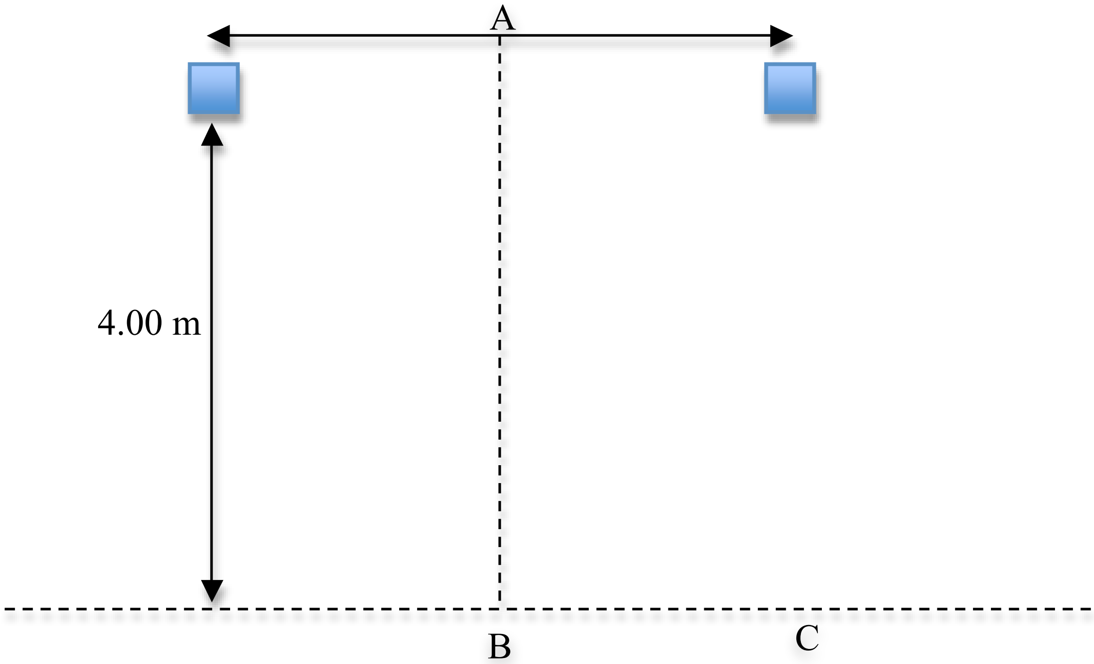
$= 9.19\ ms^{-1}$

$\tan\theta = \frac{8.35}{3.83}$ (0.5)

$\theta = 65.4°$

$9.19\ ms^{-1}$ at $65.4°$ to the horizontal
(1) (1)

4. Two speakers are set up 4.47 m apart as shown in the diagram below.



Both speakers are emitting sound of frequency 865 Hz and are in phase.

(a) What do you hear as you walk from A to B and why? [2]

- The sound would be loud as both waves reach you in phase.
- The loudness would drop as you walked towards B due to inverse square relationship.

(b) What is the wavelength of the sound being emitted? [2]

$v = 346\ ms^{-1}$
$f = 865$ Hz
$\lambda = ?$

$v = f\lambda$ (1)
$346 = (865)(\lambda)$
$\lambda = 0.40$ m (1)

(c) What would you hear at point C? Justify your answer. [3]

path diff $= \sqrt{(4.47^2 + 4^2)} - 4$
$= 6.00 - 4$
$= 2.00$ (1)

$2/0.4 = 5$ (1)
= integer number of wavelengths
∴ loud spot. (1)

(d) How many times would the intensity increase moving from C to B?

[1]

- Five

(e) Why do you perceive this difference in intensity as you walk from C to B?

[3]

- At B the sound waves are both in phase and have travelled the same distance.
- As you move towards C the length of each path is altered and the waves become alternately in and out of phase
- causing soft spots – two waves out of phase and loud points two waves in phase.

(d) If the speaker are now moved to 4.61 m apart and the speaker on the left is altered so that it is emitting a sound which is 90° in front of the signal emitted from the right speaker (ie the speakers are 90° out of phase) what would you hear at C? Justify your answer.

[3]

Path length of wave from right speaker to C is 4.0 m
This equals 10 wavelengths (1)

Path from left speaker to C is 6.1 m
This equals 15.25 wavelengths (1)

Wave from left started 0.25 wavelengths in front of right speaker and travels another 0.25 wavelengths.

This means that both sound waves will arrive in phase and you will hear a loud. (1)

5. A friend brings back from America a device that she claims to be the world's greatest coffee maker. Unfortunately it was designed to operate from a 120 V line to obtain the 960 W of power that it needs.

(a) What could you do to operate it at 120 V? [Assume Australian power lines are held at 240 V].

[2]

- Use a step down transformer
- With a turns ratio of 2:1

(b) What current will the coffee maker draw from the 240 V line?

[2]

P =960 W
V = 240 V
I = ?

P = VI (1)
960 = (240)(I)
I = 4A (1)

(c) What is the resistance of the coffee maker?

[2]

P =960 W
V = 240 V
R = ?

$P = \frac{V^2}{R}$ (1)

$960 = \frac{120^2}{R}$

R = 15 Ω (1)

Real transformers are very efficient devices, but will always experience some energy losses. One way to minimise these losses is through the use of a laminated iron core.

(d) Describe the construction of the laminations and their function in the iron core.

[4]

- Iron discs separated by insulting glue.
- Reduce energy loss due to eddy currents induced in the iron core.
- The laminations reduce the bulk material and thus limit the magnitude of the eddy currents.
- Magnetic field can still pass through.

(f) A transformer is used on a 240 V supply to deliver 9.00 A at 80.0 V to a heating coil. If 10% of the energy taken from the supply is dissipated in the transformer itself, what is the current in the primary winding?

[3]

$V_P = 240$ V
$V_S = 80$ V
$I_S = 9.00$ A
$I_P = ?$

$P_P = V_P I_P$ (1)
$P_S = V_S I_S$
$P_S = 0.9 P_P$

$(0.9)(V_P I_P) = V_S I_S$ (1)
$(0.9)(240)(I_P) = (80)(9)$
$I_P = 3.33$ A (1)

6. A closed pipe of length 60.0 cm has a standing wave produced inside it at its second overtone.

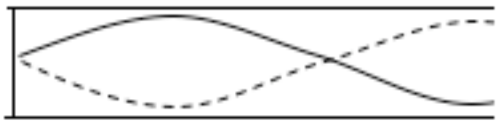
(a) What are the conditions necessary to form a standing wave in the pipe?

[2]

- Two identical waves travelling through the same medium
- in opposite directions.

(b) Draw a diagram showing the second overtone.

[2]



(c) What is the frequency of the note?

[3]

$L = \frac{3\lambda}{4}$ (0.5)

$\lambda = \frac{(4)(0.6)}{3}$

$\lambda = 0.80m$ (1)

$v = f\lambda$ (0.5)

$346 = (f)(0.80)$

$f = 433Hz$ (1)

(d) What is the minimum length of an open pipe that would be required to resonate at the fundamental frequency of the closed pipe?

[3]

$f = \frac{nv}{2L}$ (1)

$\frac{433}{3} = \frac{(1)(346)}{(2)(L)}$ (1)

$L = 1.20m$ (1)

(e) If the open pipe was heated so that the speed of sound changed by 5.00 ms^{-1} how would this effect the frequency of the resonating wave?

[3]

- If the temp of the gas increases (heating) then the velocity of the sound wave also increases.
- The length of the pipe is constant
- therefore wavelength of the fundamental must be constant and hence frequency must go up. ($v=f\lambda$)

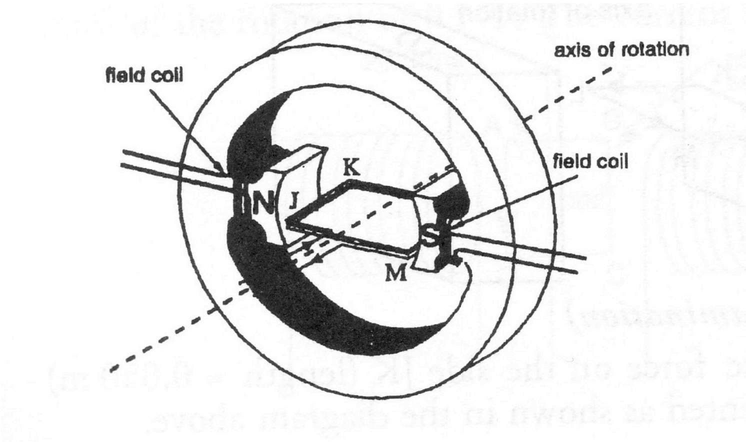
(f) What is the new frequency of the wave?

[2]

$V = 351\ ms^{-1}$ (1)
$\lambda = 2.40$ cm

$v = \lambda f$
$f = 351 / 2.40$
$= 146$ Hz (1)

7. The following questions refer to the DC motor in the diagram below.



The armature of the motor consists of a rectangular coil with 30 turns. Side JK is 15 cm long and side JM is 10 cm. The magnetic field can be considered to be radial and has a flux density of 0.05 T.

(a) Determine the maximum torque of the motor.

[3]

Torque = BANI (1)
= (0.05)(2.09)(30)(0.15)(0.10) (1)
= 4.70×10^{-2} Nm (1)

(b) Explain why it is advantageous to utilise a radial magnetic field in a motor?

[3]

- F and B are always perpendicular.
- If B is not radial, this means that angle between F and r will change (angle will be 90° when plane of coil is parallel to the field lines).
- If the angle changes, torque will not always be at the maximum value.
- In a radial field, the direction of B changes and therefore the angle between F and r is always as close as possible to 90°.

An ammeter was used to measure the current through the motor. While it was running freely, a current of 2.09 A was recorded. While the motor was running, the axle of the motor was held firmly, preventing it from rotating, and the current was recorded as 2.54 A.

(c) Explain the increase in current recorded.

[4]

- When the motor spins, the magnetic flux through the coil changes. A changing magnetic flux will lead to an induced emf.
- Lenz's law states that the flux will be in such a direction as to oppose the change that created it – hence we call it a back emf.
- The back emf opposes the applied emf, and hence the net emf decreases.
- The back emf is proportional to the rate of change of magnetic flux, if the motor is not turning, back emf decreases and current increases.

(d) If the motor operates on 9.00 V and develops a 6.50 V back emf while running freely, what current does the motor draw when it is **starting**?

[4]

$\varepsilon_{app} - \varepsilon_{back} = Ir$ (1)

$9 - 6.5 = (2.09)(r)$

$r = 1.20\Omega$ (1)

$\varepsilon_{app} = Ir$ (1)

$9 = (I)(1.20)$

$I = 7.50A$ (1)

(e) Why are you more likely to incur damage to a motor when it is first started and when it is under load?

[3]

- Back emf is proportional to rate of rotation of motor – at the start and when under load the rate of rotation is low.
- Therefore back emf is at a miniumum – therefore net emf is at a maximum.
- This means a large current will flow in the wires.

YEAR 12 PHYSICS
MID YEAR EXAMINATION 2008

SECTION C

Name:____

1. The Physics of Skipping Stones
(Adapted from: The Mystery of the Skipping Stone, Physics World Vol 19 No 2 February 2006 Bocquet L and Clanet C)

In 2002 an American called Kurt Steiner set a new world record when he threw a stone across a river in Pennsylvania and made it bounce 40 times. Most people will not have been quite as successful as Steiner, but many will be familiar with the principle of stone skipping: to throw a flattish stone across the surface of a body of water so that it bounces as many times as possible.

It has been shown that the formula that relates collision time (of a stone with the water surface) and velocity for a stone is given by;

$$T = \sqrt{\left(\frac{MR}{\rho S}\right)}\frac{1}{v}$$

where:
T is the collision time
M is the mass of the stone
R is the radius of the stone
ρ is the density of water
S is the cross-sectional area of the stone
v is the velocity of the stone

The data below pertains to a stone of dimensions:

M = 15 g; R = 3 cm; $S = 6.0 \times 10^{-5}\ m^2$

Collision Time (ms)	Velocity (ms^{-1})	1/v (sm^{-1})
56	2	0.5
37	3	0.33
22	5	0.2
16	7	0.14
12	9	0.11
10	11	0.091
7.5	15	0.067

(a) Given the formula above, what should you plot to obtain a linear graph?

[2]

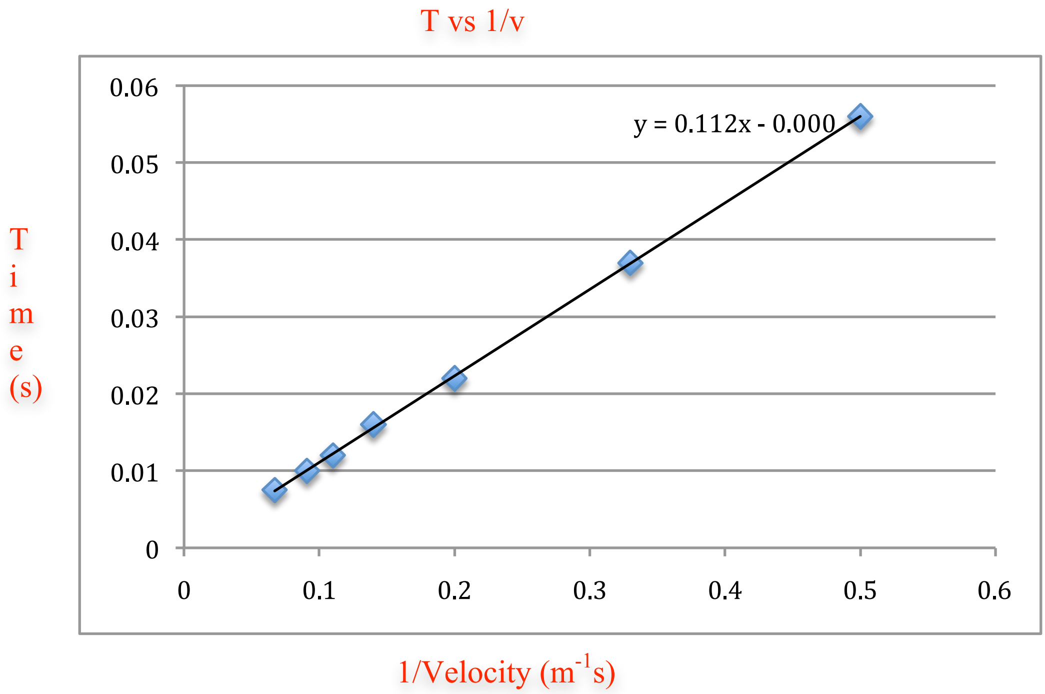
T vs 1/v

(b) Use the third column in the table on page 31 to process the given data to allow you to plot a linear graph. [Label the column appropriately]

[3]

(c) Plot the graph on the graph paper provided.

[6]



Title	1 mark
Axes Labels & Units	2 mark
Correct Points Plotted	1 mark
Linear Scales	1 mark
Line of Best Fit	1 mark

(d) Determine the gradient of your line.

[4]

- Triangle on graph – 1 mark
- Calculation – 1 mark
- Value – 0.112 – 1 mark
- Units – m

(e) Use the gradient of your curve to determine the density of water.

[3]

- Calculation – 1 mark
- Value – 1.12 x 10^3 (996)
- Units – kg m^{-3}

Experiments have also shown that a bouncing stone must spin with a certain minimum rotational velocity if it is to be stable i.e if the angle between the plane of the stone and the water surface is to remain constant. To remain stable a stone typically needs to rotate at least once during its collision time. If this rotation does not take place, the stone's collision becomes quite complex and a second bounce becomes much less likely.

(f) If a stone is to rotate at least once during its collision time, what must the minimum spin velocity be equal to [hint – you do not need to do a calculation].

[2]

- The inverse of collision time.

(g) People who are good at stone skipping, intuitively rotate stones with a flick from the finger. Why do they do this?

[2]

- Gives the stone increased spin (or rotational velocity).
- Increases the likelihood that the stone will rotate once during the collision (and therefore remain stable).

Researchers found that, surprisingly, the stone does not slow down during the skipping process, but rather the stone's trajectory 'flattens' with time. This is because the angle with which the stone moves relative to the water dictates that the stone displaces more water when it moves down than rises. This results in a smaller transfer of momentum in the latter stage of each skip and therefore in reduced lift. When the stone no longer has enough energy to jump, it simply surfs over the water before finally sinking.

The number of skips is also determined by the type of stone used and the angle at which it is thrown. And as all stone skippers know, the flatter the stone, the better!

(h) The passage describes the stone's trajectory as 'flattening'. Explain what this means with regards to changes in the horizontal and vertical components of the velocity.

[2]

- horizontal velocity stays the same
- vertical velocity decreases.

(f) Why would there be reduced lift in the latter stages of the motion?

[3]

- The stone displaces more water on the way down than on the way up.
- The greater the displacement, the greater the force on the stone and the greater the change in momentum.
- As the vertical component of the velocity decreases, the amount of water displaced is reduced and lift is proportional to the amount of water displaced.

(i) Why would a flatter stone be more effective at skipping?

[3]

- Flatter stone means greater surface area.
- As surface area increases, the amount of water displaced will be increased.
- Thereore greater change in momentum, more likely to skip up.