CHRIST CHURCH GRAMMAR SCHOOL

YEAR 11

PHYSICS ATAR YEAR 11

FINAL YEAR EXAMINATION 2017

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1		
2		
3		
Total		/156 = %

Time allowed for this paper
Reading time before commencing work: ten minutes
Working time for paper: two hours and thirty minutes

Materials required/recommended for this paper
To be provided by the supervisor
This Question/Answer Booklet
Formulae and Data Booklet

To be provided by the candidate
Standard items: pens (blue/black preferred), pencils (including coloured), sharpener, eraser, correction tape/fluid, ruler, highlighters

Special items: non-programmable calculators satisfying the conditions set by the SCSA for this course, drawing templates, drawing compass and a protractor

Important note to candidates
No other items may be taken into the examination room. It is **your** responsibility to ensure that you do not have any unauthorised notes or other items of a non-personal nature in the examination room. If you have any un-authorised material with you, hand it to the supervisor **before** reading any further.

Structure of this paper

Section	Number of questions available	Number of questions to be answered	Suggested working time (minutes)	Marks available	Percentage of exam
Section One: Short Answers	9	9	50	55	35 %
Section Two: Problem-Solving	5	5	70	76	49 %
Section Three: Comprehension	1	1	30	25	16 %
				Total	100

Instructions to candidates

1. Write your answers in this Question/Answer Booklet

2. When calculating numerical answers, show you working or reasoning clearly. Give final answers to three significant figures and include appropriate units where applicable.

3. You must be careful to confine your responses to the specific questions asked and to follow any instructions that are specific to a particular question.

4. The Formulae and Data booklet is **not** handed in with your Question/Answer Booklet.

YEAR 11
PHYSICS ATAR
FINAL EXAMINATION 2017

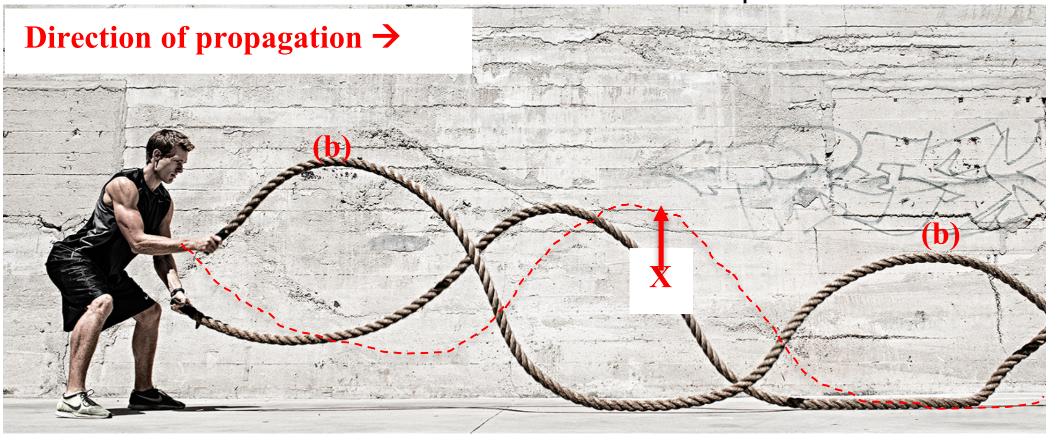
Section One: Short Response

This section has **nine (9)** questions. Answer **all** questions. Write your answers in the space provided.

Suggested working time for this section is **50 minutes**.

Question 1 **(7 marks)**

An athlete is training with 6.00 m long battle-ropes fixed to a wall as shown in the diagram, such that his hand is in a region of maximum particle displacement. He observes that as his left hand starts moving upwards, there are two crests between himself and the wall. He observes that in a 45.0 second interval he is able to produce 65 waves.



(a) State the direction of movement of the rope at point X.

(1 mark)

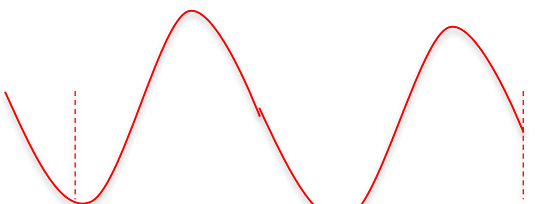
(b) On the diagram, **clearly** identify 2 points on the wave that are in phase.

(1 mark)

Any two valid points.

(c) Calculate the wavelength of the waves produced in the battle rope.

(2 marks)



$1.75\lambda = 6.00$ m (½)

$\lambda = 6/1.75$ (½)

$= 3.43$ m (1)

(1 mark if two wavelengths are assumed)

(d) Calculate the wave speed of the wave through the battle rope.

(3 marks)

f = 65 / 45

= 1.44 Hz (1)

$v = f\lambda$ (½)

= 1.44 x 3.43 (½)

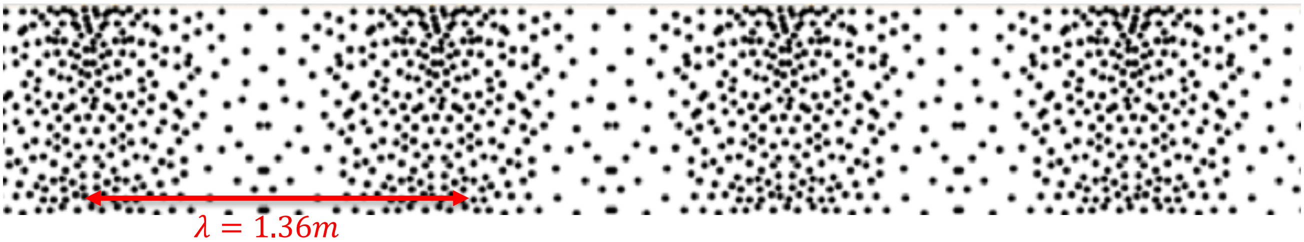
$= 4.94 \text{ ms}^{-1}$ (1)

if $\lambda = 4$m , $v = 5.78 \text{ ms}^{-1}$

if $\lambda = 3$m , $v = 4.33 \text{ ms}^{-1}$

Question 2 **(5 marks)**

The soundwave shown below is moving through the air with a distance between successive compressions of 1.36 m. The sound wave causes air particles to undergo a displacement from their equilibrium positions of 5.00 μm. The speed of sound in air is 342 ms^{-1}



(a) Calculate the frequency of the soundwave.

(2 marks)

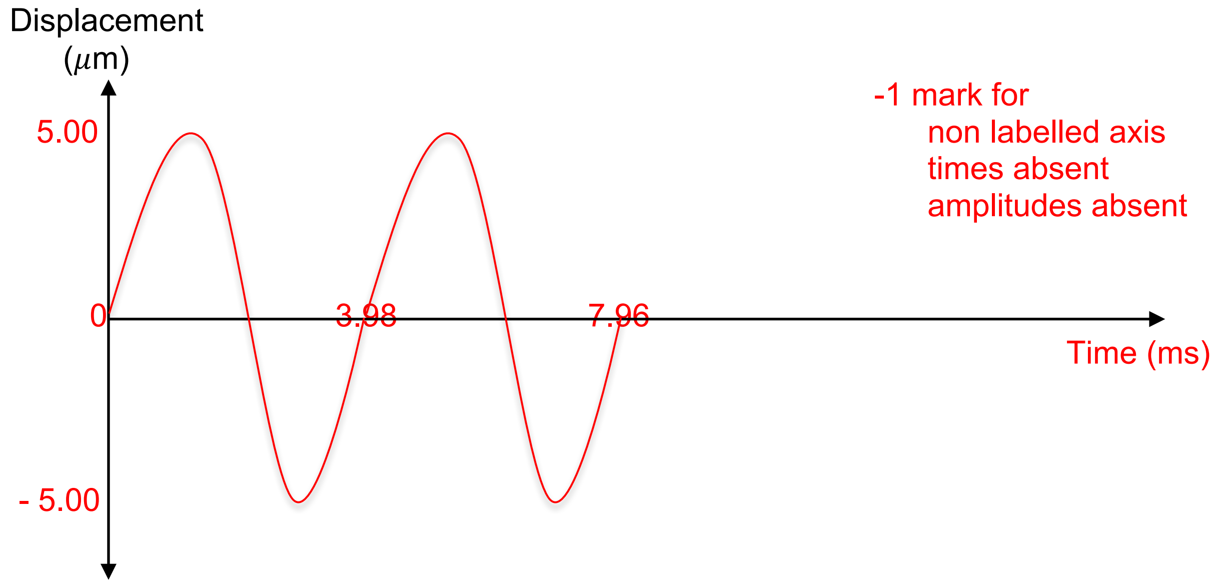
$v = f\lambda$ ½ $f = \frac{v}{\lambda} = \frac{342}{1.36}$ ½

= 251 Hz 1

(b) Sketch a labelled displacement-time graph of a particle showing two complete cycles of the sound wave passing by it.

(3 marks)

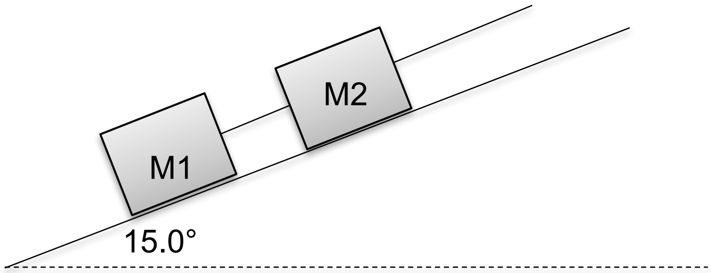
T = $\frac{1}{f} = \frac{1}{251}$ = 3.98 x10^{-3} s 1

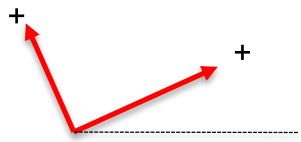


-1 mark for
non labelled axis
times absent
amplitudes absent

Question 3 **(4 marks)**

Two 4.55 kg masses are pulled up a 15.0° incline with an acceleration of 0.120 ms^{-2}. If each mass experiences a frictional force of 2.45 N between itself and the incline, determine the magnitude of the tension in the middle cable.





Consider M1

$\Sigma F = ma = F_g + T + F_F$ (1)

4.55(+0.12) = -(4.55)(9.8)sin15 +(-2.45) + T (1)

T = 0.546 + 11.5 + 2.45 (1)

= 14.5 N (1.d.p) (1)

Question 4 **(5 marks)**

A man is standing in an elevator on a set of bathroom scales. When the elevator is stationary, the scales say that the man has a “weight” of 70.0 kg. When the elevator is accelerating, the scales read 67.0 kg. Calculate the acceleration of the man.

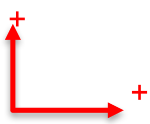
N = 67 x 9.8
= 656 N up (1)

$\Sigma F = ma = W + N$ (1)

70(a) = 70(-9.8) + 656 (1)

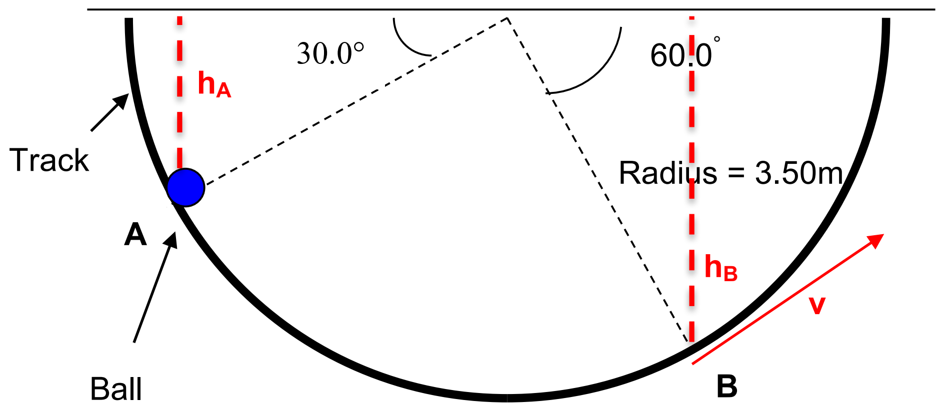
a = $\frac{-686+656}{70}$ (1)

= 0.429 ms^{-2} downwards (1)



Question 5 **(5 marks)**

A ball rolls down a perfectly curved semi-circular track of radius 3.50 m. The ball starts stationary at position A. Assuming no energy losses to friction, calculate the velocity of the ball when it reaches position B.



h_A = 3.5sin30
=1.75 m ½

h_B = 3.5sin60
= 3.03 m ½

Δh = hf - hi
= 3.03 – 1.75
= 1.28 m 1

$\Sigma E_i = \Sigma E_f$ ½

$mg\Delta h = ½ mv^2$ ½

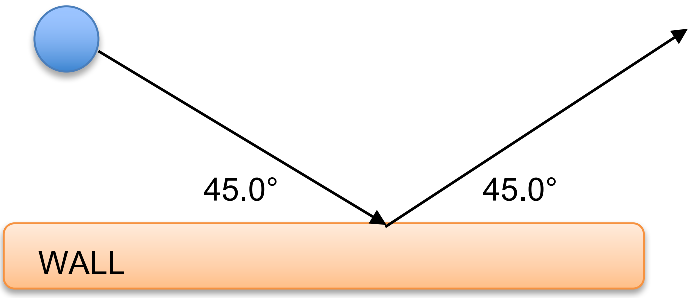
$g\Delta h = ½ v^2$ $v = \sqrt{2g\Delta h}$ ½

$= \sqrt{2(9.8)(1.28)}$ ½

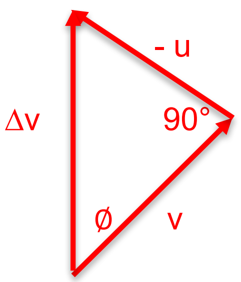
= 5.01 ms^{-1} @ 30.0° above horizontal 1

Question 6 **(8 marks)**

A 0.500kg ball travelling at 4.00 ms^{-1} strikes a wall at an angle of 45.0°. It rebounds elastically with the same speed and same angle away from the wall. The ball is seen to be in contact with the wall for a time of 20.0 ms.



(a) Calculate the change in velocity of the ball with the assistance of a vector diagram. (4 marks)



$|\Delta v| = \sqrt{4^2 + 4^2}$ (1)
$= 5.66\ ms^{-1}$

$\emptyset = tan^{-1}\left(\frac{4}{4}\right)$ (1)
$= 45.0°$

$\Delta v = 5.66\ ms^{-1}$ @ 90.0° to the wall.
(1) (1)

(angle must be calculated, via trigonometry or geometry)

(b) Calculate the force the wall exerts on the ball while it is contact (4 marks)

$F\Delta t = mv - mu$ (1)

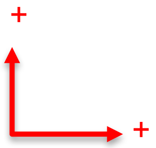
$= m(\Delta v)$

$F = \frac{m(\Delta v)}{\Delta t} = \frac{0.500(5.66)}{20 \times 10^{-3}} = 142$ N @ 90.0° to the wall.

(1) (1) (1)

Question 7 **(4 marks)**

A cart of mass 20.0 kg travelling with a velocity of 4.00 ms^{-1} South collides with a stationary cart of unknown mass. They two carts couple together and their combined velocity is 1.80 ms^{-1} South. Calculate the mass of the second cart.



$\Sigma p_i = \Sigma p_f$ (½) p = mv (½)

$m_1u_1 + \sout{m_2u_2} = (m_1 + m_2).v_2$ (1)

$20.0(-4) = (20 + m_2)(-1.8)$ (1)

$20 + m_2 = 44.4$

$m_2 = 24.4$ kg (1)

Question 8 **(7 marks)**

A constant forward force of 4.00 kN is exerted on a car of mass 1450 kg.

(a) Calculate the time the car should take to accelerate from rest to 100.0 kmh^{-1} (4 marks)

$v = 100 \div 3.6 = 27.7\ ms^{-1}$ (½)

$a = \frac{\Sigma F}{m} = \frac{4000}{1450}$ (½)

$= 2.759\ ms^{-2}$ (1)

$a = \frac{v-u}{t}$ (½)

$t = \frac{v-u}{a} = \frac{0-27.7}{2.759}$ (½)

$= 10.0$ s (1)

(b) Explain why, in reality, the car would take longer to accelerate to 100 kmh^{-1} (3 marks)

- In reality, heat would be lost to friction and air resistance
- Hence the net force on the car is actually less than 4000 N
- This would reduce the acceleration and the time taken as $t \propto \frac{1}{a}$

Question 9 **(10 marks)**

A student uses a rheostat shown. A rheostat is essentially one long piece of insulated wire wrapped helically around an insulating tube. A contact can slide along the coil and vary the length, and hence, the resistance of the wire. The wound rheostat's external dimensions are 5.10 cm diameter and 15.0 cm length. Each individual loop of wire is placed edge to edge and the diameter of the wire is 0.500 mm. If the entire length of the rheostat is used, the resistance is measured to be 100.0 Ω.

(a) Determine the length of wire in the rheostat. (4 marks)

$C = 2\pi r$

(1) $= 2\pi\left(\frac{5.05\times10^{-2}}{2}\right)$

$= 0.159$ m/loop

number of loops = 0.15 / (0.5x10^3)

(1) = 300 loops

Length = 300 loops x 0.159 m/loop (1)

= 47.7 m (1)

(b) Calculate the resistivity of the wire used in the rheostat wire using the equation:

$R = \frac{\rho L}{A}$ (if you could not complete (a), use L = 34.1m) (3 marks)

$\rho = \frac{RA}{L} = \frac{100(\pi)(\frac{0.5\times10^{-3}}{2})^2}{47.7}$ (1) (1)

$= 4.12 \times 10^{-7}$ Ωm (1)

$= \frac{100(\pi)(\frac{0.5\times10^{-3}}{2})^2}{34.1}$

$= 5.76 \times 10^{-7}$ Ωm

(c) If the rheostat is used for a prolonged amount of time, it is observed that it becomes quite hot. Explain how, if at all, this effects the resistance of the rheostat. (3 marks)

- As the temperature increases, the mean translational velocities of particles in the wire increase
- This increases the impedance that the mobile/free electrons experience as they travel through the wire
- Which increases the electrical resistance.

End of Section One

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Section Two: Problem-Solving

This section has **five (5)** questions. Answer **all** questions. Write your answers in the space provided.

Suggested working time for this section is **70 minutes**.

NAME:_______________________________________

TEACHER: CJO JRM
(please circle)

Question 1 **(17 marks)**

A group of students were given the task of finding out about the properties of a string on a violin. After some experimentation, they discovered that the frequency (f) produced by the string when played had the following relationship to the length (L) of the string, the tension (T) in the string and the linear density (μ) (mass per unit length) of the string. The symbol *k* is the proportionality constant for this relationship.

$$f = \frac{k}{L}\sqrt{\frac{T}{\mu}}$$

(a) For this equation state the proportionality between: (3 marks)

(i) f and L $f \propto \frac{1}{L}$ (1)

(ii) f and T $f \propto \sqrt{T}$ (1)

(iii) f and μ $f \propto \sqrt{\frac{1}{\mu}}$ (1)

Once the group had found the relationship between the variables, they did further experiments in an attempt to find the value of the proportionality constant of the violin string which had a mass per unit length of 0.020 kgm^{-1}. They did 5 trials by sounding the string at 5 different frequencies. A summary of their results is in the table below.

Length (L) (m)	Tension (T) (N)	Frequency (f) (Hz)	$\sqrt{\frac{T}{\mu}}$
0.80	1.56	145	8.8
0.80	3.7	225	14
0.80	9.61	379	22
0.80	11.9	412	24
0.80	15.2	492	28

1 mark = correct values

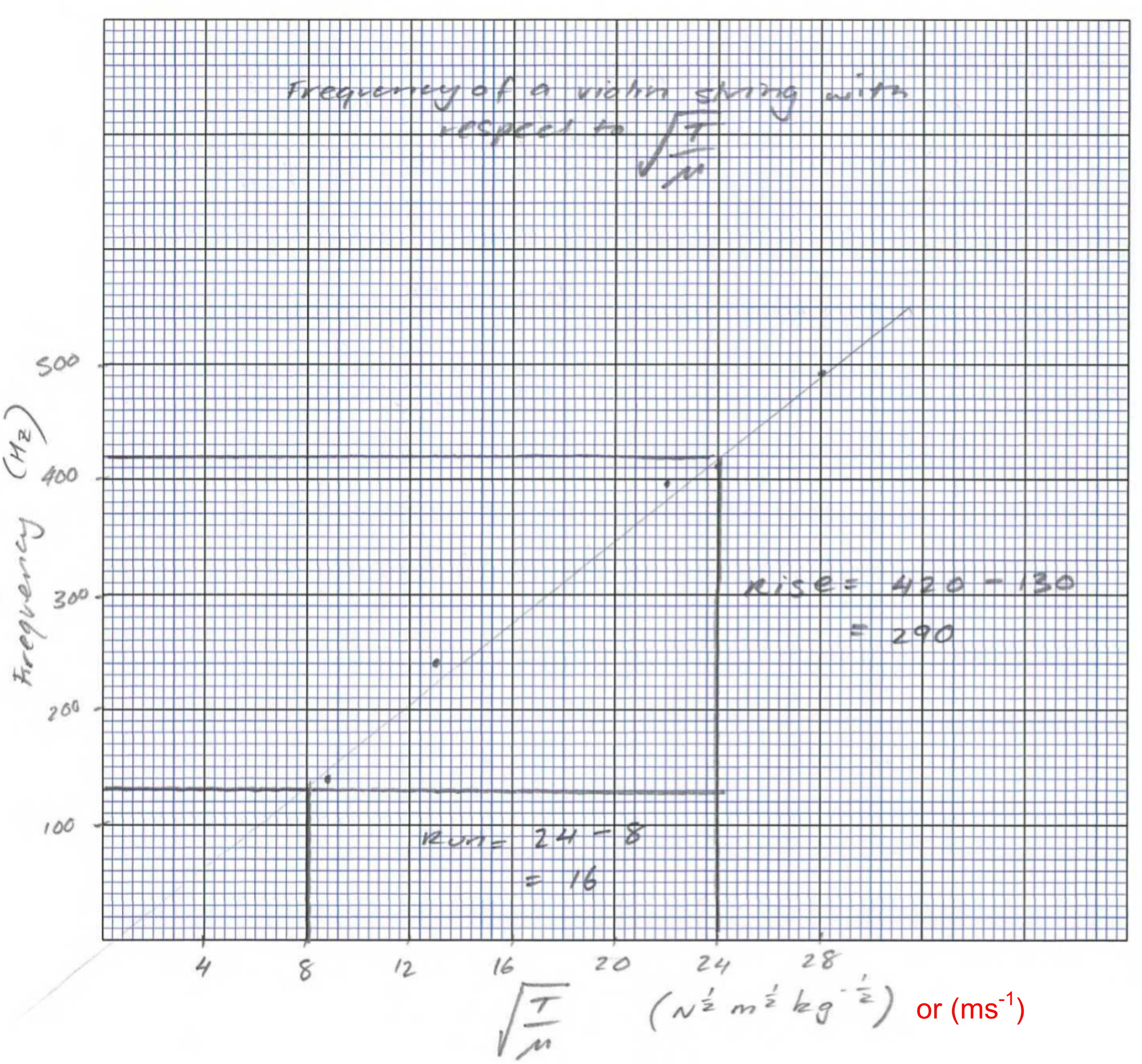
1 marks = 2 sig fig

(b) Complete the column in the table above, in order to obtain a linear relationship graphically. (2 marks)

(c) On the graph paper on the following page, plot frequency as a function of $\sqrt{\frac{T}{\mu}}$

A spare graph has been provided at the back of this booklet should you require it. (5 marks)

-1 mark for: title absent, axes labels absent, non-linear scale, incorrect plotting, LOBF absent, units absent/incorrect.



(d) Show that the proportionality constant, k, is dimensionless. The following units are provided for you:

(3 marks)

μ = [kgm^{-1}]

T = [N] = [$kgms^{-2}$]

f = Hz = [s^{-1}]

L = [m]

$k = \dfrac{Lf}{\sqrt{\frac{T}{\mu}}}$ (1)

$= \dfrac{[m][s^{-1}]}{\left[\frac{kgms^2}{kgm^{-1}}\right]^{1/2}}$

$= \dfrac{[m][s^{-1}]}{[m^2 s^{-2}]^{1/2}}$ (1)

$= \dfrac{[m][s^{-1}]}{[m][s^{-1}]}$ = no dimensions (1)

(e) Use the gradient to calculate the proportionality constant.

(4 marks)

m = rise / run

= (420-130) / (24-8)

= 18 s^{-1} / ms^{-1}

= 18 s

$m = \frac{k}{L}$

k = m L

= 18 x 0.8

= 14.4

(2 marks for determining gradient)
(1 mark for omission of units for gradient)

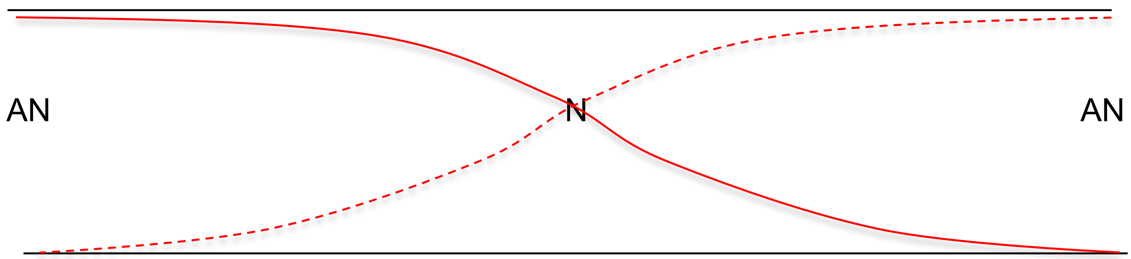
(2 marks for determining k constant)

Question 2 **(13 marks)**

A pipe organ has a particular pipe which acts as an open pipe of length 76.0 cm when sounded.

(a) Sketch the displacement envelope (graph) for the fundamental mode of vibration of air within the pipe.

(2 marks)



1 mark – shape correct
½ mark – even spacing
½ mark – 1 line being dashed.

(b) Calculate the frequency of the fundamental harmonic when the pipe is playing on a day when the speed of sound in air is 342 ms^{-1}.

(3 marks)

$$f(n) = \frac{nv}{2L} = \frac{1 \times 342}{2(76 \times 10^{-2})} = 225 \text{ Hz}$$

① ① ①

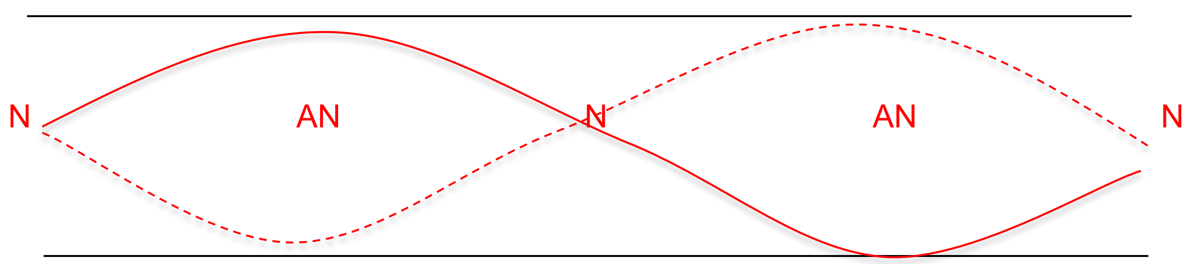
(c) State and **explain how the pitch** of the note produced by the pipe would change if the temperature of air decreased.

(3 marks)

- the speed in air is proportional to temperature, as T decreases, so too does v
- from the wave equation, v = fλ, with λ being fixed,
- if v decreases, then frequency, **hence pitch must decease** to produce the standing wave.

(d) Sketch the pressure envelope (graph) for the first overtone within the pipe.

(2 marks)



1 mark – shape correct
½ mark – even spacing
½ mark – 1 line being dashed.

(e) A person standing 10.0 m away hears a sound with an intensity of "x" Wm^{-2}. Calculate the intensity, in terms of "x", another person would hear if they were positioned 2.50 m away from the organ.

(3 marks)

$I \propto \frac{1}{r^2}$ ½

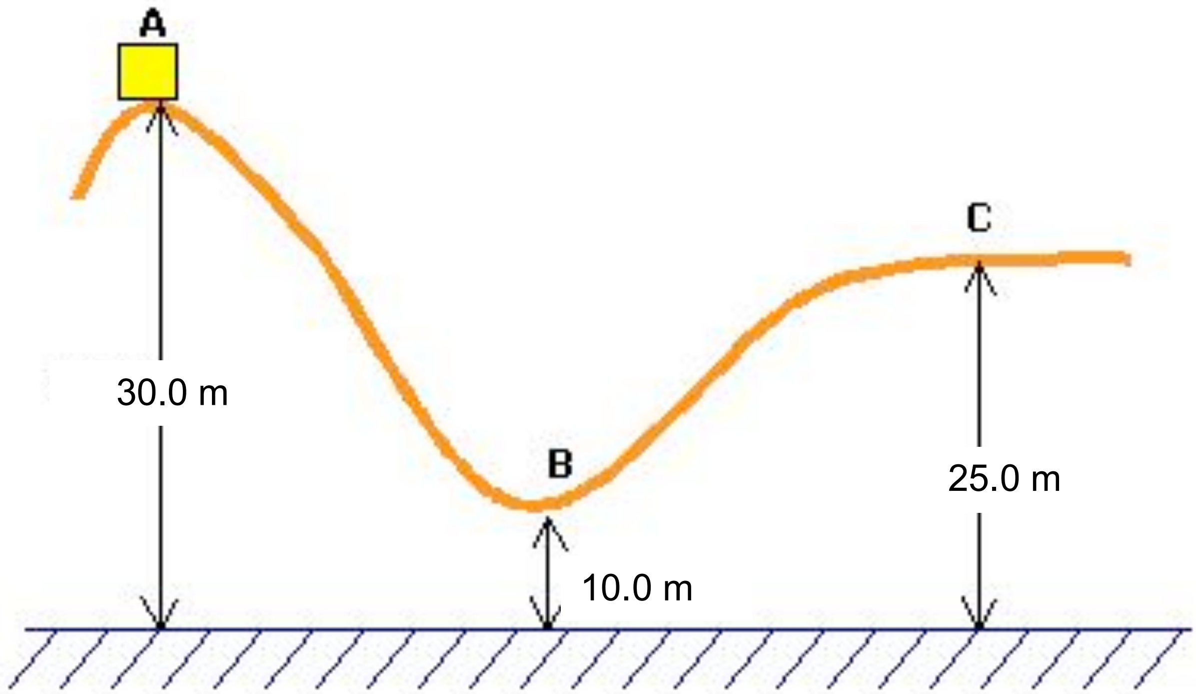
$I_1 r_1^2 = I_2 r_2^2$ ½ $I_2 = \frac{I_1 r_1^2}{r_2^2}$ ½

$= \frac{x(10)^2}{2.5^2} = 16.0x\ Wm^{-2}$

½ 1

Question 3 **(15 marks)**

Consider the roller coaster track in the picture below. The Cart has a total mass of 6.00×10^2 kg and an initial velocity (point A) of 5.00 ms^{-1}.



(a) Calculate the Total energy of the system.

(3 marks)

$\Sigma E_i = mgh_i + \frac{1}{2}mu^2$ (1)

$= 600(9.8)(30) + ½(600)(5^2)$ (1)

$= 1.84 \times 10^5$ J (1)

(b) Calculate the kinetic energy of the roller coaster at point B, ignoring friction.

(3 marks)

$\Sigma E_i = \Sigma E_f = E_{kf}$

$E_{kf} = \Sigma E_i - E_{pf}$ (1) For clear logic

$= 1.84 \times 10^5 - mgh_f$

$= 1.84 \times 10^5 - (600)(9.8)(10)$ (1)

$= 1.25 \times 10^5$ J (1)

(c) Calculate the speed of the rollercoaster at point C, ignoring friction.

(4 marks)

$\Sigma E_i = \Sigma E_f = E_{kf} + E_{pf}$ ½

$E_{kf} = \Sigma E_f - E_{pf}$

= 1.84 x10^5 - mgh_f

= 1.84 x10^5 – (600)(9.8)(25)

= 37000 J

2

v = $\sqrt{\frac{2E}{m}} = \sqrt{\frac{2(37000)}{600}} = 11.1\ ms^{-1}$

½ 1

(d) The roller coaster is only seen to be travelling at 2.00 ms^{-1} at point C. Calculate the Energy lost to friction from point A to Point C.

(3 marks)

$\Sigma E_f = E_{kf} + E_{pf} + E_{lost}$ ½

$E_{lost} = E_f - E_{pf} - E_{kf}$ ½

= 1.84 x10^5 – (600)(9.8)(25) – ½(600)(2^2) 1

= 3.58 x10^4 J 1

(e) Calculate the efficiency of this energy transfer from point A to Point C.

(2 marks)

$\mathcal{E} = \frac{Eout}{Ein} \times 100 = \frac{Ep+Ek}{Ein} \times 100$ ½

$= \frac{600(9.8)(25)+\frac{1}{2}(600)(2^2)}{1.84\times10^5} \times 100$ ½

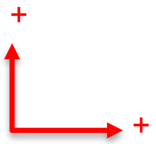
= 80.5% 1

Question 4 **(13 marks)**

A football player kicks a football vertically into the air with an initial velocity of 11.0 ms^{-1}. The ball leaves the player's foot at a height of 1.20 m above the ground and the player is 1.80 m tall.

(a) Calculate the time the player has to get out of the way of the football if he wants to avoid being hit on the head by the ball on the way down.

(5 marks)



$\Delta s = 1.80 - 1.20$ (1)
$= 0.60m$

$v = \sqrt{u^2 + 2as}$

$= \sqrt{11^2 + 2(-9.8)(0.60)}$

$= \pm\ 10.45\ ms^{-1}$ (take negative for downwards velocity) (2)

$t = \frac{v-u}{a} = \frac{-10.45-11}{-9.8}$ (½) (½)

$= 2.19\ s$ (1)

(b) Calculate the greatest height above the ground reached by the football.

(3 marks)

set v = 0

$v^2 = u^2 - 2as$ (½)

$s = \frac{v^2-u^2}{2a} = \frac{0-11^2}{2(-9.8)}$ (½) (½)

$= 6.17 + 1.20 = 7.37m$ (½) (1)

(c) Calculate the speed of the football at the moment of impact with the **ground**.

(3 marks)

Set s = -1.20

v = $\sqrt{u^2 + 2as}$ (1)

= $\sqrt{11^2 + 2(-9.8)(-1.20)}$ (1)

= $\pm$ 12.0 ms^{-1} (take negative for downwards velocity)

(1)

(d) What is the direction of the acceleration at the following positions of the ball's flight?

(2 marks)

(i) On the way up Down (½)

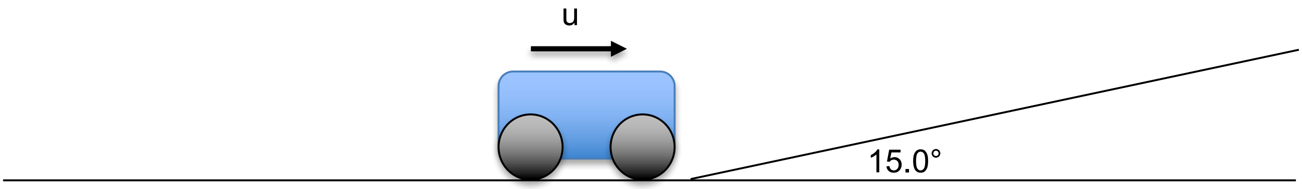
(ii) On the way down Down (½)

(iii) As the ball strikes the ground. Up (½)

(iv) As the ball is sitting stationary on the ground. None/Zero (½)

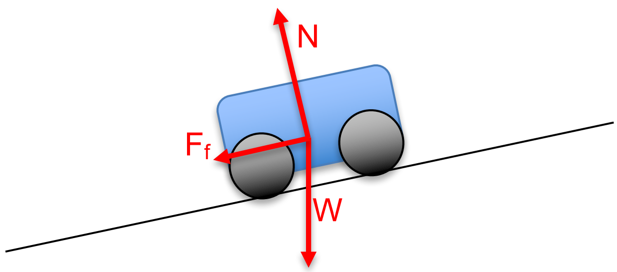
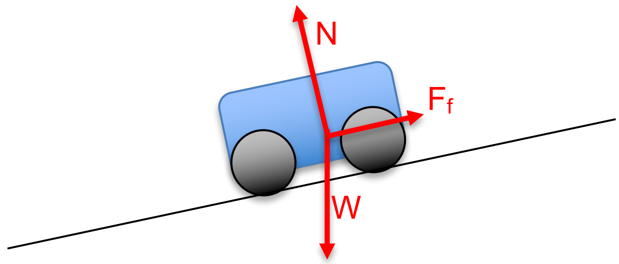
Question 5 **(18 marks)**

Consider a cart of mass 4.00 kg approaching an incline of 15.0° to the horizontal. The cart arrives at the incline with a speed of 3.50 ms^{-1} and a constant frictional force of 2.50 N acts on the cart. The cart travels up a certain distance before stopping and returning back down the incline. Ignore any effects of air resistance or friction on the level track.



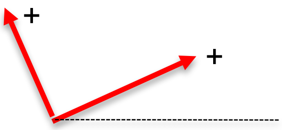
(a) Draw the forces that act on the cart for the following scenarios:

(4 marks)

(i) Travelling up the incline.	(ii) Travelling down the incline.
	

(b) Calculate the net force acting on the cart as it travels up the incline.

(3 marks)



$\Sigma F = ma = F_g + F_f$ (1)

$= mg\sin\theta + (-2.5)$

$= 4(-9.8)\sin 15 - 2.5$ (1)

= 12.6 N down the incline. (1)

(c) Calculate the distance up the incline that the cart travels before coming to rest.
If you could not complete part (b), use ΣF = 8.60N (4 marks)

$a = \frac{\Sigma F}{m} = \frac{-12.6}{4}$ (½) (½) → $a = \frac{\Sigma F}{m} = \frac{-8.60}{4}$

= -3.15 ms^{-2} (1) = - 2.15 ms^{-2}

$s = \frac{v^2-u^2}{2a} = \frac{0-(3.5^2)}{2(-3.15)}$ = 1.94 m (1) (½) (½)

$= \frac{v^2-u^2}{2a} = \frac{0-(3.5^2)}{2(-2.15)}$ = 2.85 m

(d) Using the distance from (c), Calculate the total work done due to friction as the cart travels both up and down the incline. (if you could not do (c), use s = 2.85m)

(3 marks)

total s = 2x 1.94

= 3.88 m (1)

W = F_f x s (½)

= 2.50(3.88) (½)

= 9.70 J (1)

W = F_f x s

= (2.50)(2.85 x 2)

= 14.3 J

(e) Using energy principles, calculate the speed of the cart as it leaves the incline.

(4 marks)

$E_{Total} = E_{kf} + E_{lost}$ (½)

$E_{kf} = E_{Total} - E_{lost}$

½mv^2 = ½mu^2 – 9.70

= ½(4)(3.5^2) – 9.70

= 14.8 J (2)

$v = \sqrt{\frac{2E}{m}} = \sqrt{\frac{2(14.8)}{4}} = 2.72\ ms^{-1}$ (½) (1)

End of Section Two

YEAR 11
PHYSICS ATAR
FINAL EXAMINATION 2017

Section Three: Comprehension

This section has **one (1)** question. Answer **all** questions. Write your answers in the space provided.

Suggested working time for this section is **30 minutes**.

NAME:____

TEACHER: CJO JRM
(please circle)

Question 1 **(25 marks)**

Take-off is the phase of flight in which an aerospace vehicle goes from the ground to flying in the air. For aircraft taking off horizontally, this usually involves starting with a transition from moving along the ground on a runway.

Fixed-wing aircraft designed for high-speed operation (such as commercial jet aircraft) have difficulty generating enough lift at the low speeds encountered during take-off. These aircraft are therefore fitted with high-lift devices, often including slats and flaps, which increase the camber (angle to horizontal) and cross-sectional area of the wing. This makes the wings more effective at low speed by creating more lift. These are deployed from the wing before take-off and retracted during the climb. They can also be deployed at other times, such as before landing.

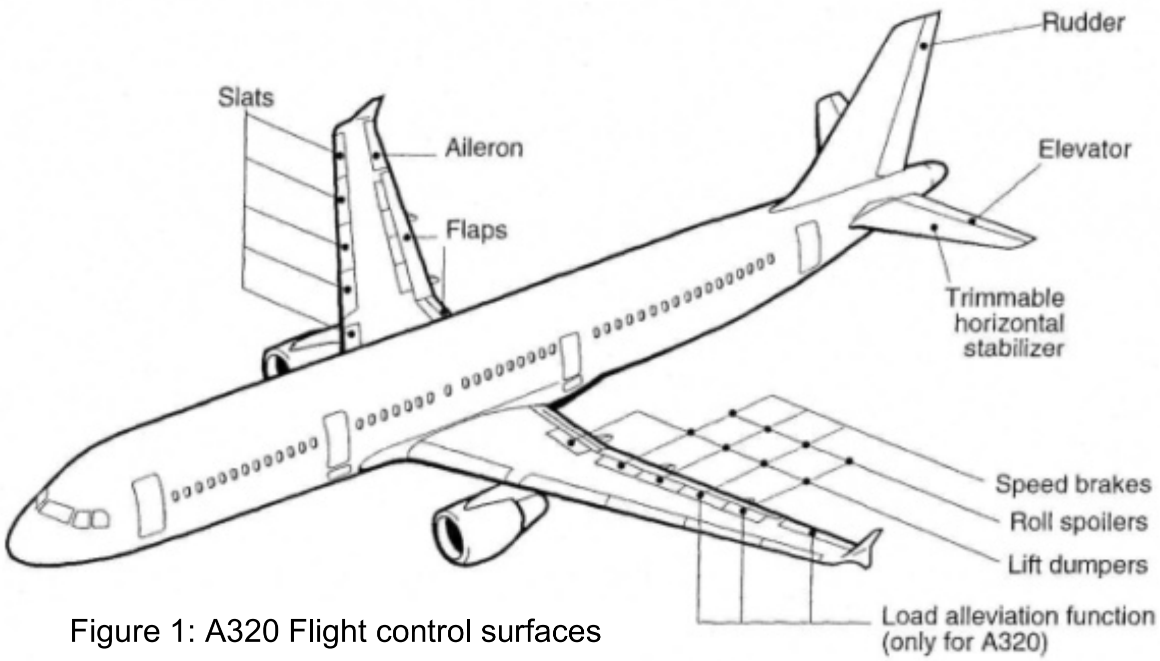


Figure 1: A320 Flight control surfaces

The speeds needed for take-off are relative to the motion of the air (indicated airspeed). A headwind (wind approaching the wings from the front of the aircraft) will reduce the ground speed needed for take-off, as there is a greater flow of air over the wings. Typical take-off air speeds for jetliners are in the 130–155 knot range (240–287 km/h).

Though air is very light, it has mass and is affected by gravity. Therefore, like any other substance, it has weight, and because of its weight, it exerts force. Since it is a fluid substance, this force is exerted equally in all directions, and its effect on bodies within the air is called pressure. The density of air has significant effects on the airplane's performance. As air becomes less dense, it reduces:

- Power; because the engine takes in less air,
- Thrust; because the propeller is less efficient in thin air, and
- Lift; because the thin air exerts less force on the wing.

The take-off speed required varies with air density, aircraft gross weight, lift coefficient, and aircraft configuration (flap or slat position, as applicable). Air density is affected by factors such as field elevation and air temperature; the lower the temperature, the higher the density. This relationship between temperature, altitude, and air density can be expressed as a density altitude, or the altitude in the International Standard Atmosphere at which the air density would be equal to the actual air density.

Aircraft employ the concept of the “take-off V-Speeds”, V_1, V_R and V_2. These speeds are determined not only by the above factors affecting take-off performance, but also by the length and slope of the runway and any peculiar conditions, such as obstacles off the end of the runway. At speeds below V_1, a take-off can be aborted but above V_1, the take-off can no longer be aborted; the pilot continues the take-off and returns immediately for landing. After the co-pilot calls V_1, he/she will call V_R or "rotate," marking the speed at which to rotate the aircraft for ascent. The V_R for fixed-wing aircraft is calculated to allow the aircraft to reach a required minimum height clearance at V_2 with one engine failed. Then, V_2 (the safe take-off speed) is called. This speed must be maintained after an engine failure to meet performance targets for rate of climb and angle of climb.

ASSOCIATED CONDITIONS:

POWER .... 1. TAKE-OFF POWER SET BEFORE BRAKE RELEASE
2. BOTH ENGINES IDLE AT V_1 SPEED
AUTOFEATHER .... ARMED
BRAKING .... MAXIMUM
RUNWAY .... PAVED, LEVEL, DRY SURFACE

WEIGHT – POUNDS	V_1 – KNOTS
16,600	108
16,000	107
14,000	102
12,000	102
10,000	102

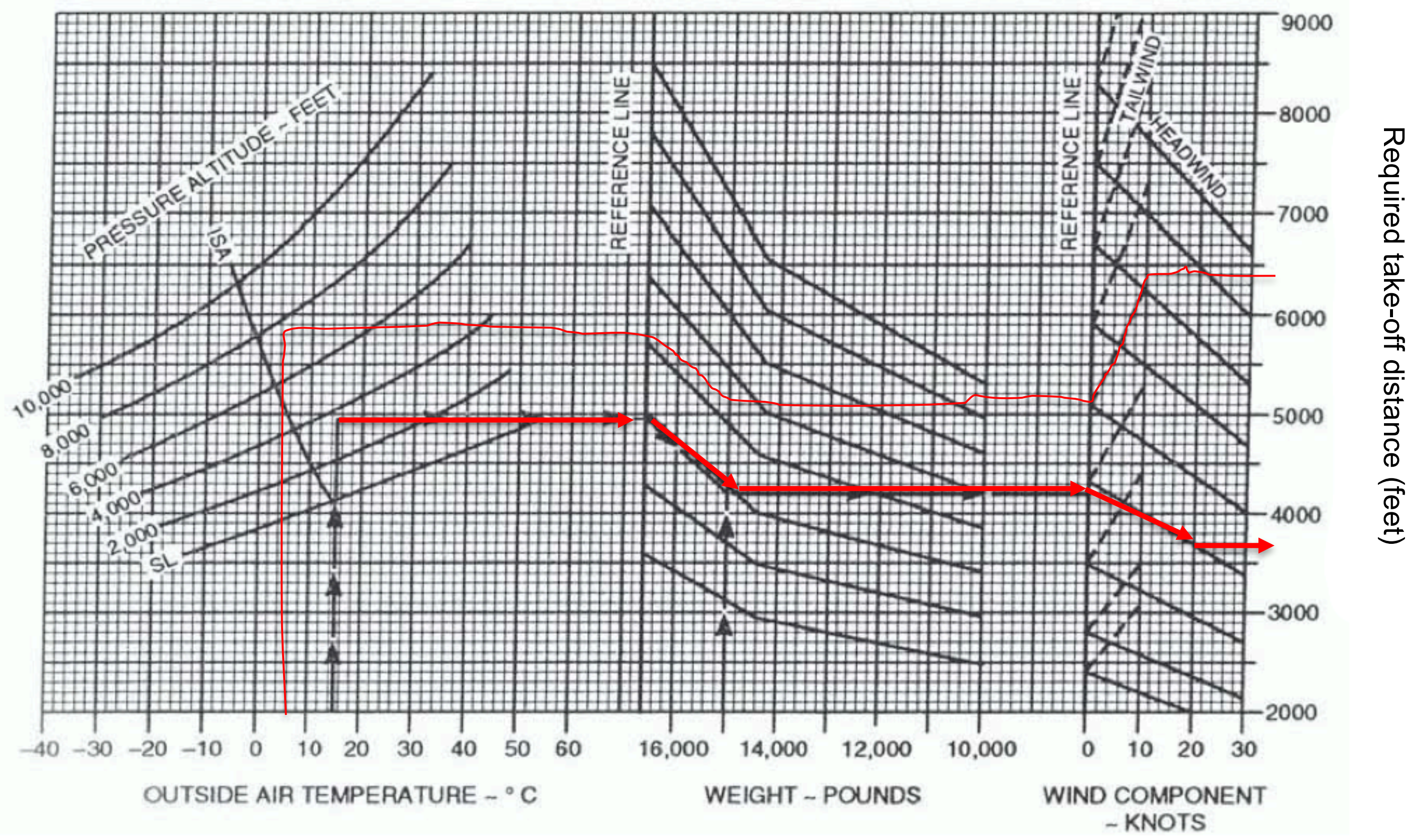


Figure 2: Take-off Runway distance for a light, twin-engine aircraft

In a single-engine or light twin-engine aircraft, the pilot calculates the length of runway required to take off and clear any obstacles, to ensure sufficient runway to use for take-off. A safety margin can be added to provide the option to stop on the runway in case of a rejected take-off. In most such aircraft, any engine failure results in a rejected take-off as a matter of course, since even overrunning the end of the runway is preferable to lifting off with insufficient power to maintain flight.

If an obstacle needs to be cleared, the pilot climbs at the speed for maximum climb angle (Vx), which results in the greatest altitude gain per unit of horizontal distance travelled. If no obstacle needs to be cleared, or after an obstacle is cleared, the pilot can accelerate to the best rate of climb speed (Vy), where the aircraft will gain the most altitude in the least amount of time. Generally speaking, Vx is a lower speed than Vy, and requires a higher pitch angle to achieve.

(a) Calculate the speed of 1 knot in ms^{-1}. Express your answer to 3 significant figures.

(2 marks)

$\frac{240\ km/h}{130\ knots}$ = 1.85 km/h per knot (1)

÷ 3.6 = 0.514 ms^{-1} per knot

(1)

(b) Explain why fixed-wing air craft have difficulty in generating lift at low speeds.

(2 mark)

- The cross-sectional area (camber) of the wing is quite low
  (Relative to the motion of the air over the wings.) – not required
- Only a minimal portion of airflow is directed vertically, hence providing minimal lift

(c) Explain how a head wind reduces the required take-off speed for a fixed-wing aircraft.

(2 marks)

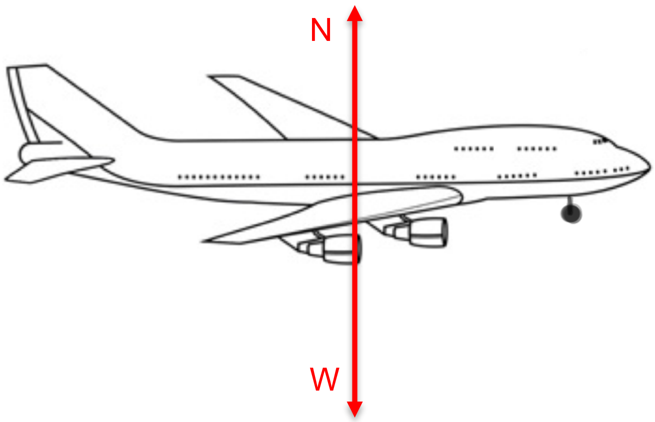
- A headwind increases the airspeed over the wings which increase Lift for a given speed.
  - Meaning the aircraft does not need to travel as far to reach the requires airspeed for takeoff.

  OR
  - Take off speed is relative to airspeed, meaning the aircraft does not need to reach such a high ground speed for takeoff.

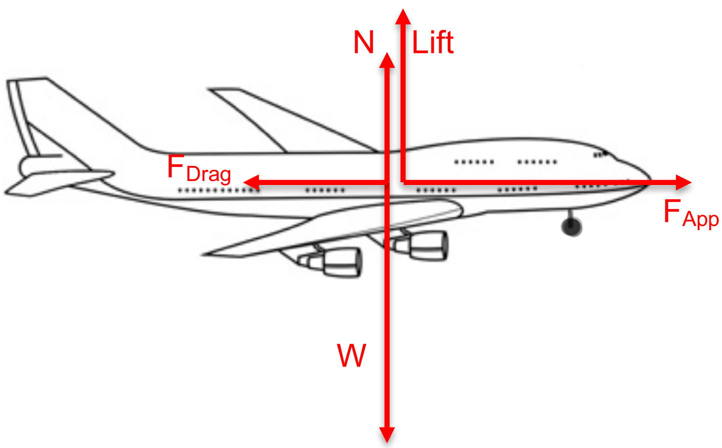
(d) State what cannot occur at speeds below V_1 and explain why this cannot occur.
(3 marks)

- Take-off cannot occur if there is a critical failure
- As the air-craft does not have sufficient airspeed to reach VR
- Therefore cannot generate enough lift for full take off

(e) The diagram below shows a plane stationary on the runway. Draw all of the forces acting on the plane at this time.
(2 marks)



(f) The diagram below shows a plane travelling at a speed less than V_1 but accelerating towards V_R. Draw all of the forces acting on the plane at this time.
(3 marks)



*1 mark off if Normal is not reduced compared to (e), due to the introduction of Lift.

In order to determine the required runway distance, a pilot uses the graph in figure 2. The pilot starts on the bottom-left side of graph with temperature, follows the y-axis to the runway's height above sea level (S.L.), then follows the graph across to “air-craft weight” and then finally to any air speed present during take-off. The red line on Figure 2 shows a twin-engine aircraft taking off in certain conditions. The required take-off distance is determined to be 3700 feet.

(g) Determine the altitude of the runway.

(1 mark)

3600 - 3800 feet

(h) Determine the wind speed and direction relative to the runway.

(2 marks)

20 knot head wind

A pilot using the same aircraft needs to take-off on a runway that is 8,000 feet above sea level (SL) with an air temperature of 5.00 °C. The plane has a total weight of 15,000 pounds and there is a tail wind of 10 knots.

(i) On the graph in figure 2, draw a line across graph to determine the required take-off distance. State this distance below.

(2 marks)

6400 feet

(j) Using the graph in figure 2, state how the weight of the air-craft affects the required take-off distance. Explain why using your knowledge of motion and forces.

(3 marks)

- increasing the weight, increases the required lift for takeoff
- hence, increasing the required airspeed over the wings
- this would require the plane to accelerate for a longer period of time and distance to reach V2

OR

- If the mass of the aircraft is increased it has more inertia
- Given a constant thrust/applied force from the planes engines
- this would reduce the acceleration of the plane and take a longer distance to reach V2

(k) Using the graph in figure 2, state how the air temperature on the runway affects the required take-off distance. Explain why.

(3 marks)

- The greater the temperature, the greater the take-off distance.
- As the temperature increases, the density decreases
- This reduces the effects of thrust, lift and power of the aircraft.

End of Section Three

Acknowledgements
Section One Q1
http://www.topstretch.com/wp-content/uploads/2016/07/benefits-of-battle-ropes.jpg

Comprehension
https://en.wikipedia.org/wiki/Takeoff
http://lms.aeroflot.ru/data/CUP/planes/A320_systems/rightframe9.html
https://www.americanflyers.net/aviationlibrary/pilots_handbook/chapter_9.htm