Rossmoyne Senior High School

ATAR course examination, 2022

Semester 1

Question/Answer booklet

PHYSICS
UNIT 3

Student number: In figures

In words ______________________________

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TIME ALLOWED FOR THIS PAPER

Reading time before commencing work: Ten minutes
Working time for the paper: Three hours

MATERIALS REQUIRED/RECOMMENDED FOR THIS PAPER

To be provided by the supervisor:
- This Question/Answer Booklet; Formula and Constants sheet

To be provided by the candidate:
- Standard items: pens, pencils, eraser or correction fluid, ruler, highlighter.

- Special items: Calculators satisfying the conditions set by the SCSA for this subject.

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 unauthorised 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 Response	11	11	50	54	30
Section Two: Problem Solving	7	7	90	90	50
Section Three: Comprehension	2	2	40	36	20
			Total	180	100

Instructions to candidates

1. The rules for the conduct of Western Australian external examinations are detailed in the *Year 11 Information Handbook 2021.* Sitting this examination implies that you agree to abide by these rules.

2. Write your answers in this Question/Answer Booklet.

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

   When estimating numerical answers, show your working or reasoning clearly. Give final answers to a maximum of **two** significant figures and include appropriate units where applicable.

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

5. Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.
   - Planning: If you use the spare pages for planning, indicate this clearly.
   - Continuing an answer: If you need to use the space to continue an answer, indicate in the original answer space where the answer is continued, i.e. give the page number. Refer to the question(s) where you are continuing your work.

Section One: Short Response **30% (54 Marks)**

This section has **eleven (11)** questions. Answer **all** questions. Write your answers in the space provided.

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

When estimating numerical answers, show your working and reasoning clearly. Give final answers to a maximum of **two** significant figures and include appropriate units where applicable.

Supplementary pages for planning/continuing your answers to questions are provided at the end of the Question/Answer booklet. If you use these pages to continue an answer, indicate at the original answer where the answer is continued, i.e. – give the page number.

Suggested working time for this section is 50 minutes.

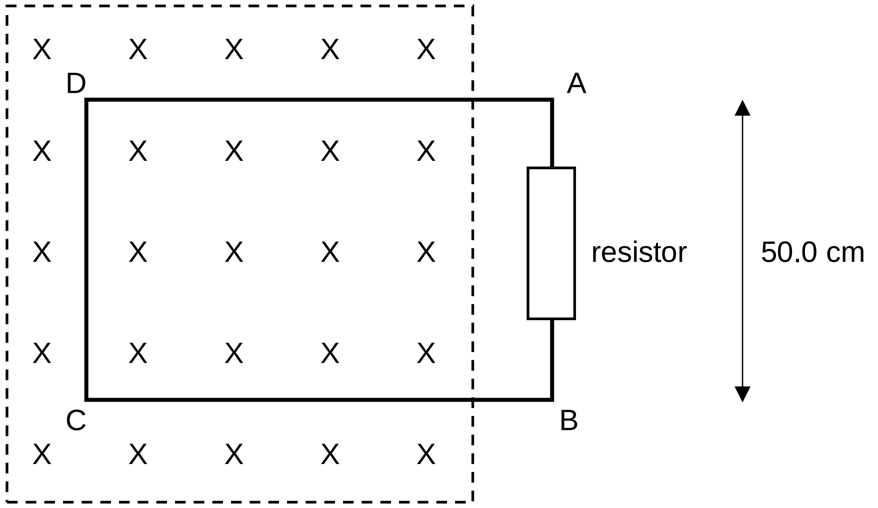
Question 1 **(3 marks)**

A generator consists of 150 turns of an armature of dimensions 15.0 cm by 25.0 cm. It is spun at a frequency of 50.0 Hz in a uniform magnetic field of 0.500 T. Calculate the EMF_{RMS} produced by the generator.

EMF_{RMS} __________________ V

Question 2 **(6 marks)**

A rectangular loop of wire ABCD is moving in a uniform magnetic field with the plane of the loop at right angles to the magnetic field, as shown. The magnetic field has strength 8.55×10^{-1} T and a resistor of 0.0130 Ω is attached between A and B. The loop moves to the right at 0.0250 m s^{-1} and as a result a constant current is induced in the loop.



(a) Determine the magnitude of the induced current flowing in the loop ABCD. (3 marks)

current ________________ A

(b) Identify the direction of the induced current **through the resistor (section AB)** and indicate with an arrow on the diagram. (1 mark)

(c) With reference to Faraday's law and the flux within the loop ABCD, explain why the current in the loop is constant. (2 marks)

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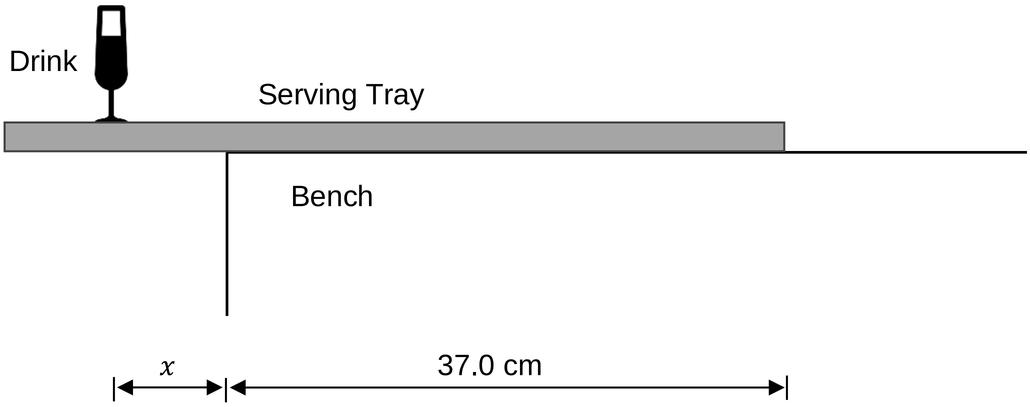
Question 3 **(3 marks)**

A drink is placed on a serving tray that is hanging over the edge of a bench. The drink has a mass of 0.290 kg and is placed on the uniform 54.0 cm long serving tray of mass 0.370 kg.

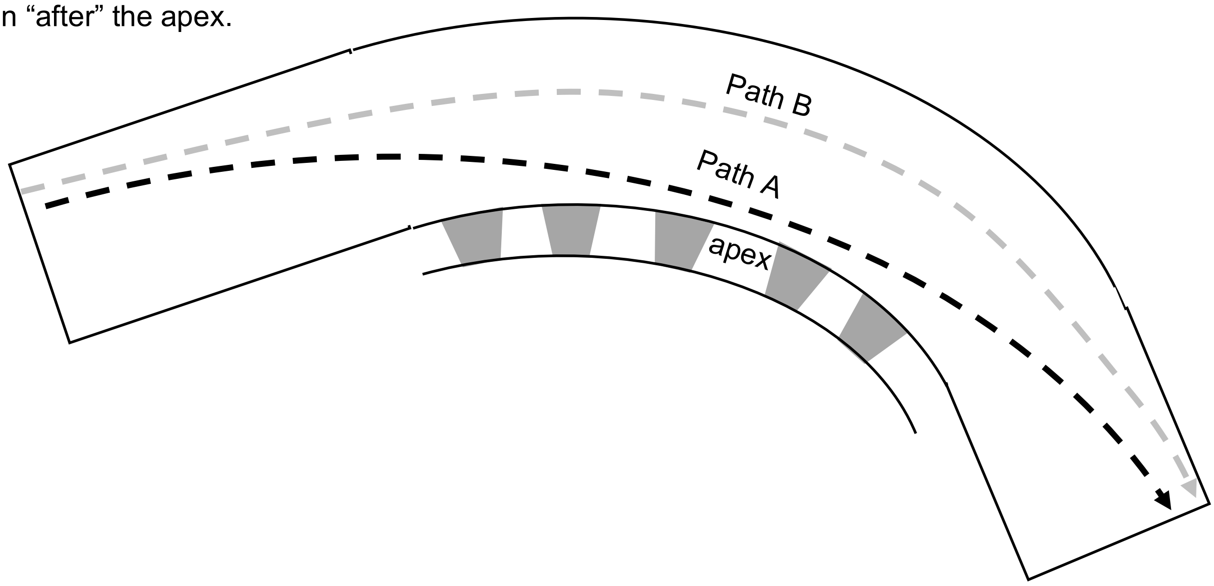


Determine the minimum distance x from the edge of the bench that the drink can be placed which will make the tray unstable.

minimum distance ________________ cm

Question 4 **(7 marks)**

Racing car drivers will often speak of 'hitting the apex'; aiming for the mid-point of the curvature of a corner in order to complete the turn at the fastest speed possible. Consider the two possible paths for a racing driver to take. Path A hits the apex, whilst path B runs wider and turns in "after" the apex.



(a) Explain, making reference to relevant equations, why a car would be able to complete path A at a faster speed compared to path B.

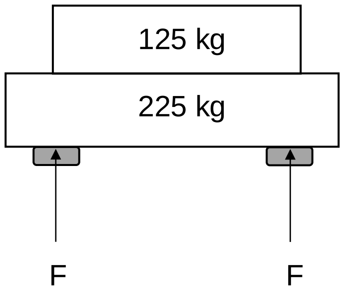
(4 marks)

(b) Calculate the radius of curvature of a path for a 1305 kg car completing a turn at 90.0 km h^{-1} with a maximum centripetal force of 35.6 kN.

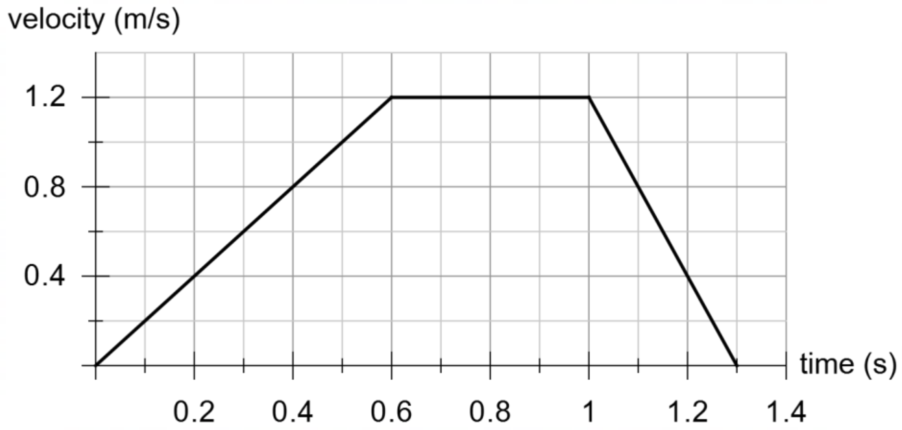
(3 marks)

Question 5 **(4 marks)**

A forklift is lifting two boxes of fruit of masses 225 kg and 125 kg off the ground, by applying a force F on each fork of the forklift.



The vertical velocity of the fruit boxes (positive upwards) was measured over the 1.30 seconds it took to lift the boxes to their maximum height and is shown on the graph below.

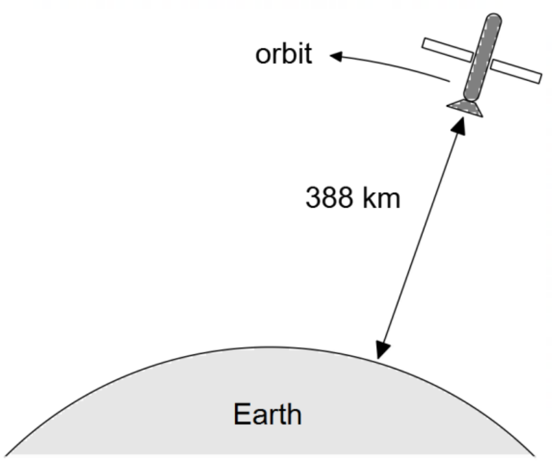


Determine the maximum force F that each fork exerts over the 1.30 s.

max force F ____________________ N

Question 6 **(4 marks)**

A 255 kg satellite is put into a low Earth orbit at an altitude of 388 km.



(a) Calculate the orbital speed of the satellite in m s^{-1}. (2 marks)

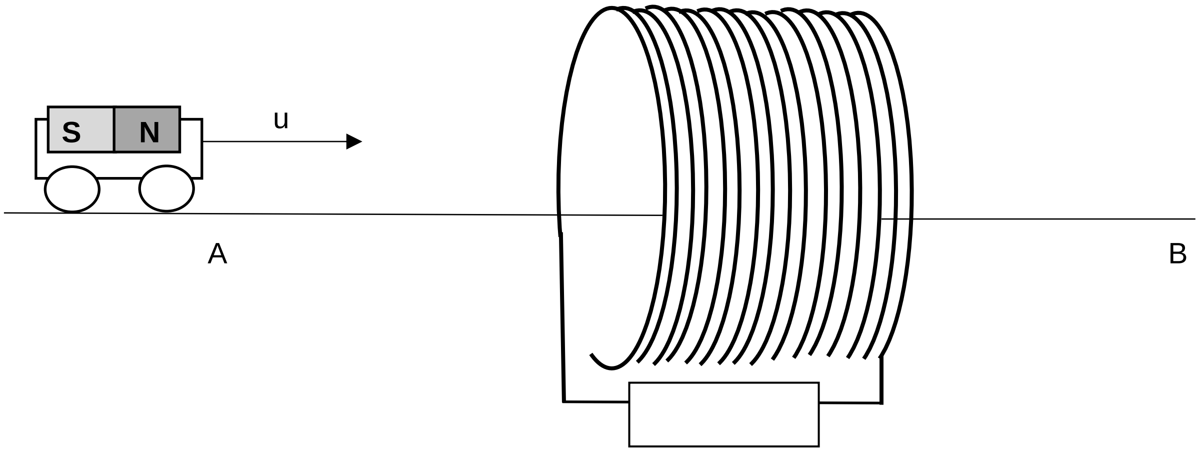
orbital speed ____________________ m s^{-1}

(b) Calculate the magnitude of the acceleration experienced by the satellite in orbit. (2 marks)
If you could not obtain an answer to part (a), use $v = 8.00 \times 10^3$ ms^{-1}.

acceleration ____________________ m s^{-2}

Question 7 **(5 marks)**

A permanent magnet is placed on a cart and rolled through a long solenoid (coil of insulated wire) with an initial speed 'u'. The solenoid is connected to a resistor as shown below.



(a) As the North pole of the magnet approaches the solenoid, state the direction of the induced current through the Resistor by drawing an arrow in the rectangle above.

(1 mark)

(b) On the axis below, sketch a labelled current-time graph flowing through the resistor as the magnet travels from point A to point B.

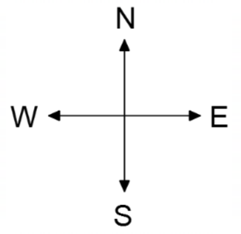
(2 marks)

(c) Explain why, when the magnet is travelling within the solenoid, there is no current flowing through the resistor.

(2 marks)

Question 8 **(4 marks)**

A Calcium ion (Ca^{2+}) travelling in an easterly direction at 0.445% of the speed of light in a magnetic field experiences a force of 2.20×10^{-14} N to the south. Find the magnitude and direction of magnetic field influencing the Calcium ion. Ignore any relativistic effects.

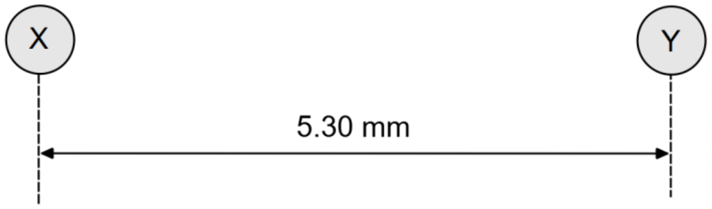


magnitude ______________________ T

direction ________________________

Question 9 **(5 marks)**

Two charged particles X and Y are 5.30 mm apart. Particle X has an electric charge of +7.48 µC while particle Y has an electric charge of –6.12 nC.



(a) Calculate the magnitude of the force exerted by particle X on particle Y. (3 marks)

force ____________________ N

(b) What is the magnitude of the electric field strength at X due to particle Y. (2 marks)

electric field strength ____________________ $N\ C^{-1}$

Question 10 **(7 marks)**

A mechanic is trying to loosen the nut on a large piece of machinery by placing a 45.0 cm long wrench on the nut in a horizontal position. The nuts require a torque of 775 Nm to loosen. The mechanic has a mass of 67.0 kg.

(a) Demonstrate, with a suitable calculation, that the mechanic is unable to loosen the nut by simply standing on the end of the wrench. (2 marks)

(b) Unable to loosen the nut, the mechanic slides a long metal tube onto the end of the wrench such that the total arm length is now 1.25 m (still in a horizontal position).

(i) Explain how this will make loosening the nut easier. (2 marks)

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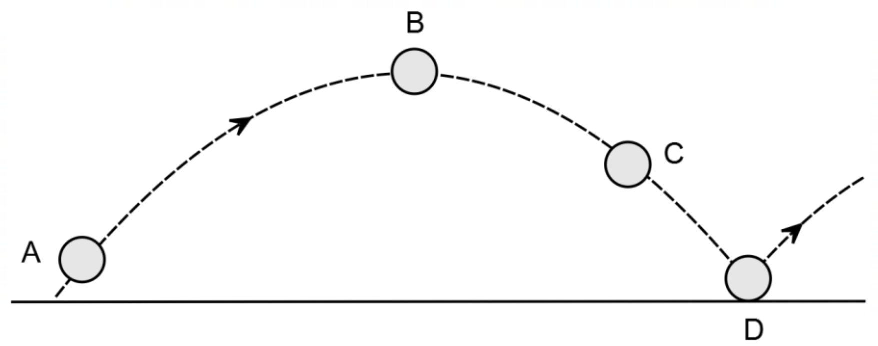
(ii) When the mechanic stands on the wrench, starting horizontally, through what angle will the nut rotate before stopping? Assume the mechanic doesn't slip. (3 marks)

rotation angle ____________________ °

Question 11 **(6 marks)**

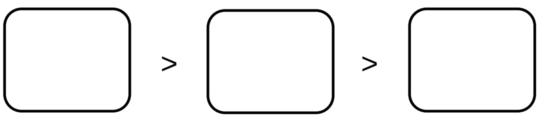
A soccer ball is kicked and follows a trajectory through points A – D as shown below. At point A the ball has just been kicked, at B the ball has reached maximum height, at C the ball is at half its maximum height and at D the ball makes maximum contact with the ground (bounces).
Note: the diagram is not to scale.



(a) On the diagram, draw a vector representing the **net acceleration** of the soccer ball at points A, B and C. Ignore friction and air resistance. (3 marks)

(b) On the diagram, draw a vector representing the **net force** on the soccer ball at point D. Ignore friction and air resistance. (1 marks)

(c) Assuming that the path of the soccer ball shown on the diagram above involves air resistance, arrange the magnitudes of the **net acceleration** on the ball at positions A, B and C (a_A, a_B, a_C), in the boxes below. (2 marks)



Section Two: Problem Solving **50% (90 marks)**

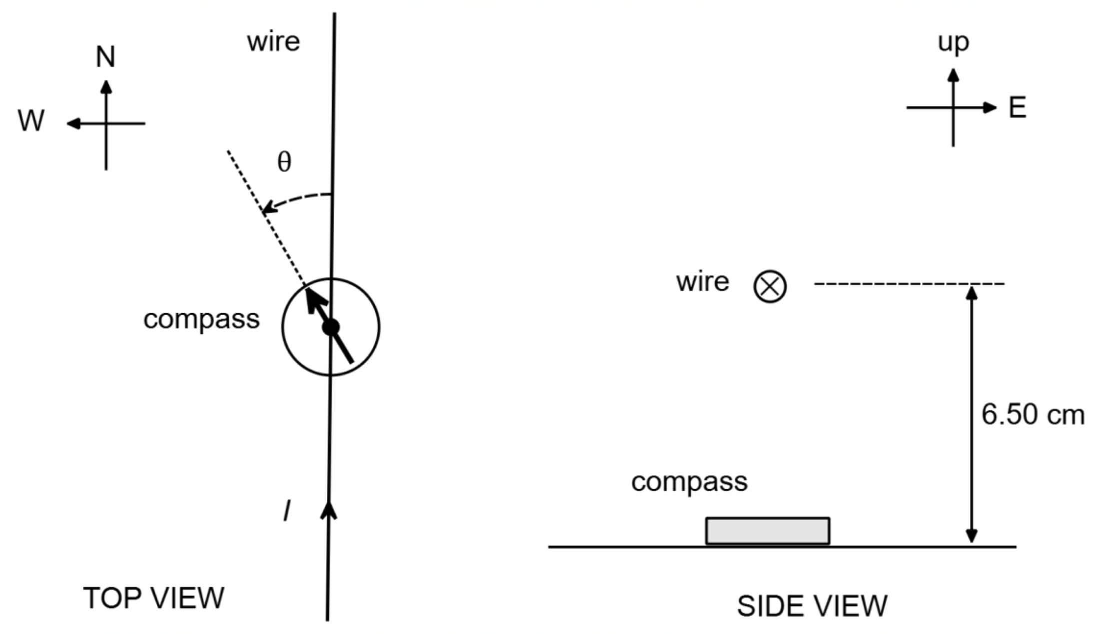
This section has **seven (7)** questions. Answer **all** questions. Write your answers in the space provided.

Suggested working time for this section is 90 minutes.

Question 12 **(19 marks)**

A student sets up a horizontal wire in a north-south direction in a region where the horizontal component of the earth's magnetic field is known to be between 50 μT and 60 μT. The student placed a very sensitive compass on the bench 6.50 cm directly below the horizontal wire.

The student then passed a current through the wire and noticed that the compass deflected through an angle θ relative to north.



(a) On the SIDE VIEW, draw the shape of the magnetic field near the wire due to the current in the wire, drawing at least 3 field lines. (3 marks)

(b) Explain why the compass changes direction when the current is turned on. (2 marks)

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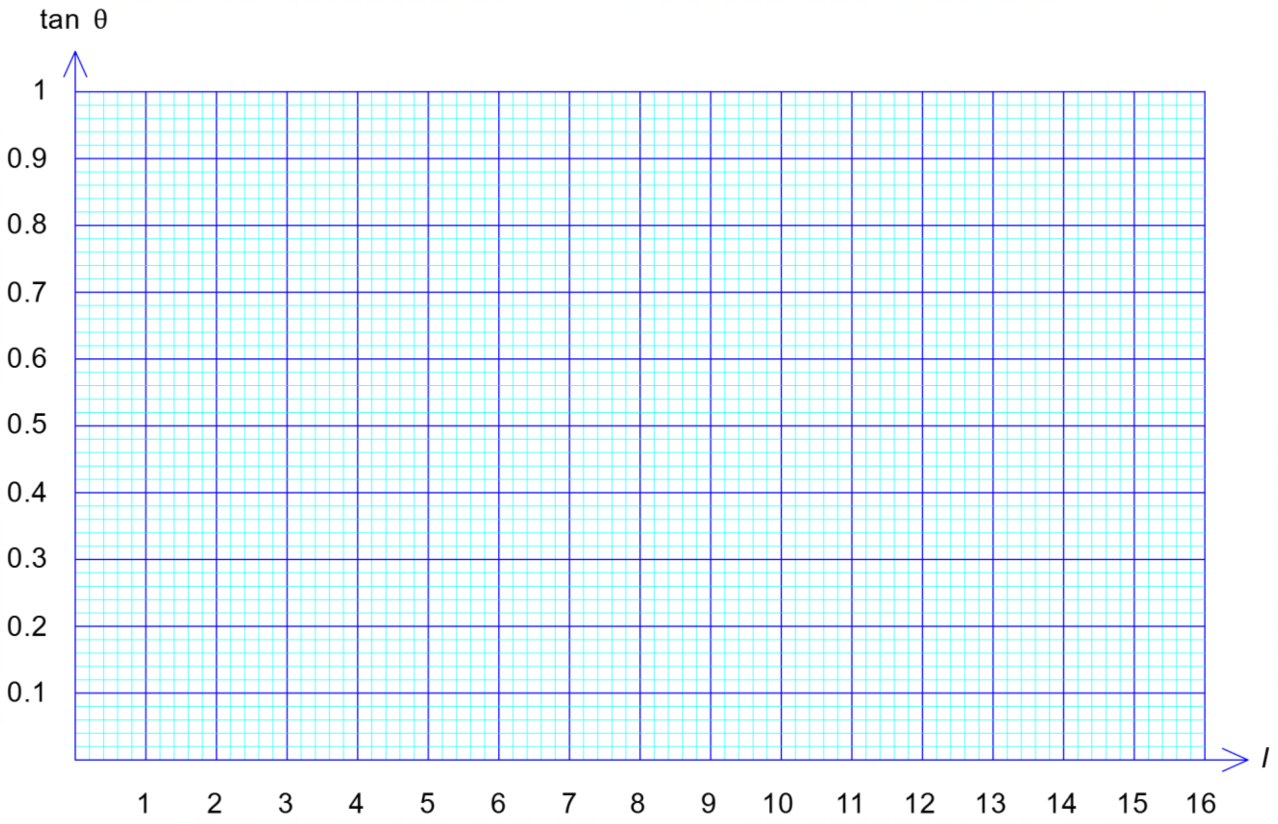
The student measured the angle of deflection for various currents and recorded these below.

Current in the wire I (A)	Angle of deflection θ	$\tan\theta$
5.18	15.7°	0.282
6.20	21.8°	0.400
7.50	25.5°	0.478
10.2	32.6°	0.640
12.1	35.1°	0.702
14.7	40.5°	0.855

(c) The student decided to construct a graph of $\tan\theta$ versus I. Using a vector diagram and a relevant formula, show that the gradient m of the line of best fit of the graph is given by the following expression, where B_e is the horizontal component of the earth's magnetic field near the wire. (4 marks)

$$m = \frac{\mu_0}{2\pi r B_e}$$

(d) Using the values in the table on the previous page, complete the graph of $\tan\theta$ versus I and draw a line of best fit on the graph. (3 marks)



(e) Calculate the gradient of the graph, showing your construction of the gradient on the graph. The units are given below. (4 marks)

gradient ____________________ A^{-1}

(f) Using your gradient, estimate the strength of the horizontal component of the earth's magnetic field close to the wire. (3 marks)

____________________ μT

Question 13 **(14 marks)**

During the Apollo 11 mission, the *Columbia* service module remained in orbit around the moon while the *Eagle* lunar module descended to the lunar surface with Buzz Aldrin and Neil Armstrong. The Columbia positioned itself at an orbital altitude of 112 km above the Moon's surface.

(a) Show the derivation of Kepler's 3^{rd} Law.

(4 marks)

(b) Hence, calculate the orbital period of the Columbia service module.

(2 marks)

(c) Calculate the orbital speed of the Columbia service module.

(2 marks)

Question 13 (continued)

When the Eagle lunar module, of mass 7810 kg approached the lunar surface, it fired thrusters in the final 50.0 m of its descent to reduce its approach speed from 15.0 m s^{-1} to rest. This provided an average deceleration of 2.25 m s^{-2} upwards. Ignore any reduction in mass due to exhausting gas.

(d) Using the information above and from your formulae sheet, calculate the weight of the Eagle lunar module in the final 50.0 m of descent.

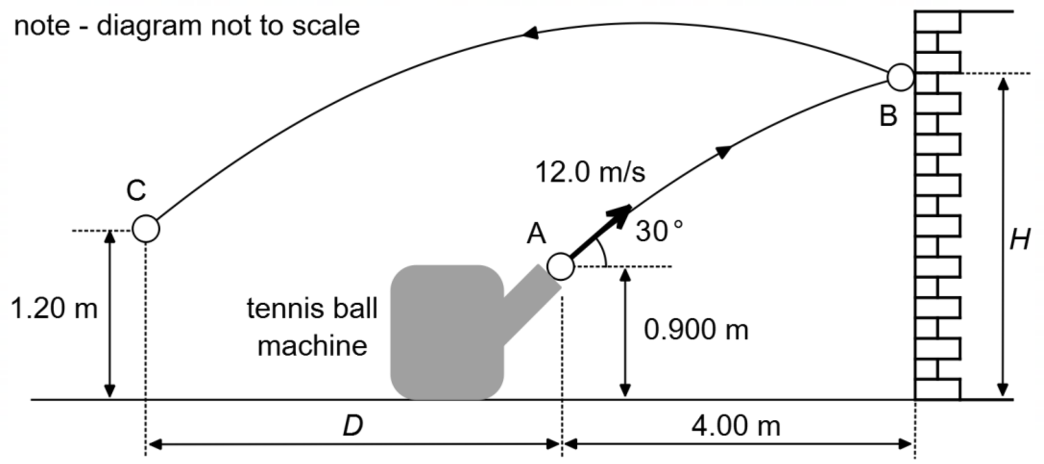
(3 marks)

(e) Hence, calculate the average force that must be applied by the thrusters to produce this average acceleration. If you could not obtain an answer to part (d), use $F_g = 1.50 \times 10^4$ N.

(3 marks)

Question 14 **(13 marks)**

A tennis ball throwing machine is set up 4.00 m from a vertical brick wall and fires a tennis ball at 12.0 m s^{-1} at 30.0° above the horizontal at a height of 0.900 m off the ground. The ball strikes the wall at point B and rebounds at the same angle (above the horizontal) it struck the wall with. The ball then travels along the projectile path shown until point C, where it is struck by a tennis player.



Assuming the collision with the wall is perfectly elastic and ignoring the effects of friction and air resistance, calculate:

(a) the angle to the horizontal the ball strikes the wall at point B. (4 marks)

angle ________________ °

(b) the speed of the ball as it leaves the wall at point B. (2 marks)

speed ________________ m s^{-1}

(c) the height *H* of the ball at point B. (3 marks)

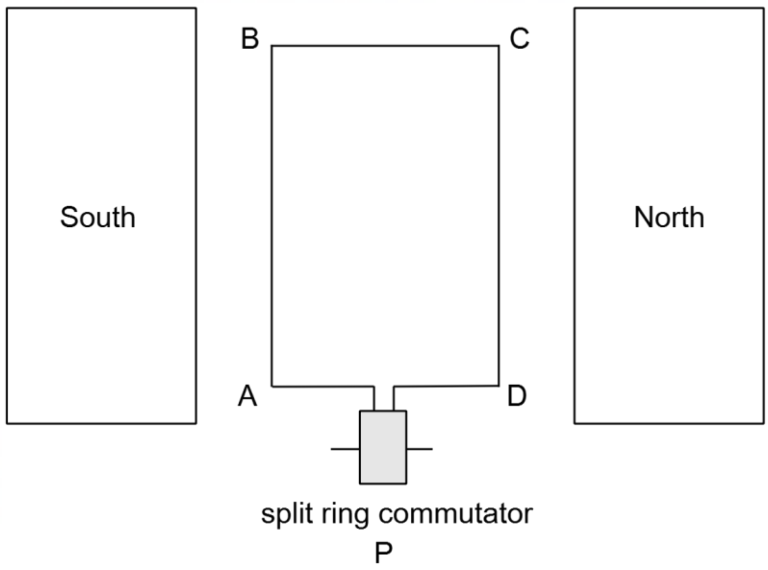
height ________________ m

(d) the horizontal distance *D* the tennis player must position themselves at to hit the ball at C. (4 marks)

distance ________________ m

Question 15 **(10 marks)**

A student constructed a simple DC motor using a length of wire, a magnet, and a voltage source. The student shaped the wire into a rectangular coil ABCD with 10 turns of wire having dimensions AB = 12.0 cm and BC = 8.00 cm. The coil sits in a magnetic field of strength 0.840 T, is supplied with a 2.75 A current and, from the perspective of point P, rotates clockwise.



(a) Determine the direction of the current flowing in coil ABCD (as viewed from above) – clockwise or anticlockwise? Circle your answer. (1 mark)

CLOCKWISE ANTICLOCKWISE

(b) Determine the maximum torque generated by the coil. (4 marks)

torque ___________________ N m

(c) Explain the function and purpose of the split ring commutator. (2 marks)

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(d) The student got the motor running but noticed that there was a reduction in the net voltage across the coil as it rotated. Further, the student noticed that this drop in voltage increased as the speed of the motor increased. Account for these observations using relevant physics. (3 marks)

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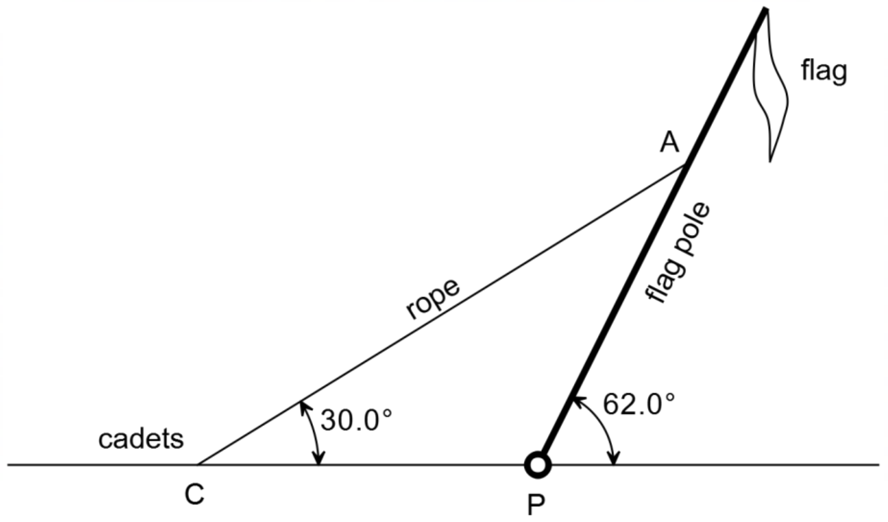
Question 16 **(14 marks)**

A group of cadets are using a rope to slowly lift a 4.20 m long flagpole into a vertical position, by pivoting the flagpole about point P. The cadets at point C simply walk backwards pulling the rope. The rope (of negligible mass) is attached to the flagpole at point A two-thirds up the flagpole. At a certain moment, as indicated, the 9.10 kg uniform flagpole and the rope make an angle of 62.0° and 30.0° with the horizontal respectively and are in equilibrium. A flag of mass 0.755 kg hangs from the end of the flagpole.



(a) Show that the tension in the rope is approximately 70 N. (5 marks)

(b) Determine the magnitude of the reaction force and the direction relative to the horizontal, of the reaction force of the ground acting on the pivot at point P. Note: if you did not calculate part (a) you may use the value of 70 N for tension in the rope. (5 marks)

magnitude ___________________ N

direction/angle ____________________ °

(c) Describe and account for how the magnitude of the tension force in the rope changes as the flagpole is raised closer to vertical. (4 marks)

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Question 17 **(10 marks)**

A council plans to install a wind-powered generator to transmit electricity several kilometres along a transmission line to a step-down transformer, designed to provide approximately 240 V RMS for several houses.

(a) The generator produces 325 kW RMS of power at 840 V RMS and the 7.80 km transmission line has a resistance of 9.00×10^{-2} ohms per kilometre of line.

(i) What RMS voltage is delivered to the transformer? (4 marks)

voltage ___________________ V

(ii) The transformer has 1400 windings on the primary side and 400 windings on the secondary side. What RMS voltage is delivered to the houses? (2 marks)

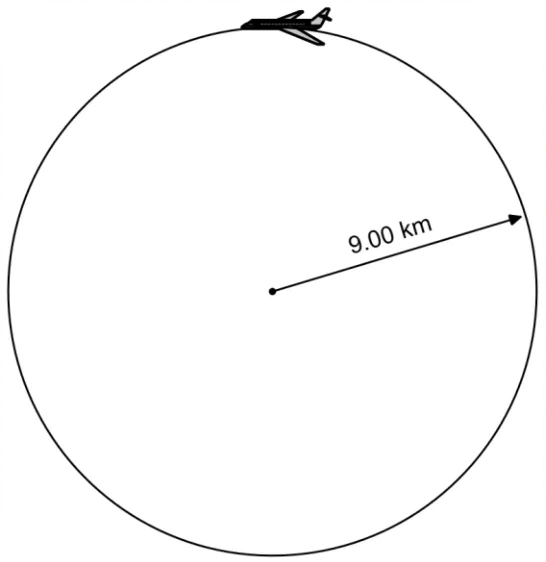
voltage ___________________ V

(b) Residents of the houses are concerned about the significant power loss in the transmission lines from the generator to the transformer. Select a type of transformer that could be installed at the generator which would reduce power loss in the transmission lines. Justify your answer using relevant physics. (4 marks)

Step–Up Transformer Step–Down Transformer

Question 18 **(10 marks)**

A 75.0 kg pilot is flying an aircraft around an airport while waiting to land. The pilot is flying the plane in a horizontal circular path of radius 9.00 km as shown. Each revolution about the airport takes 525 seconds to complete.



(a) Determine the magnitude of both the centripetal force and centripetal acceleration on the pilot during this horizontal flight. (4 marks)

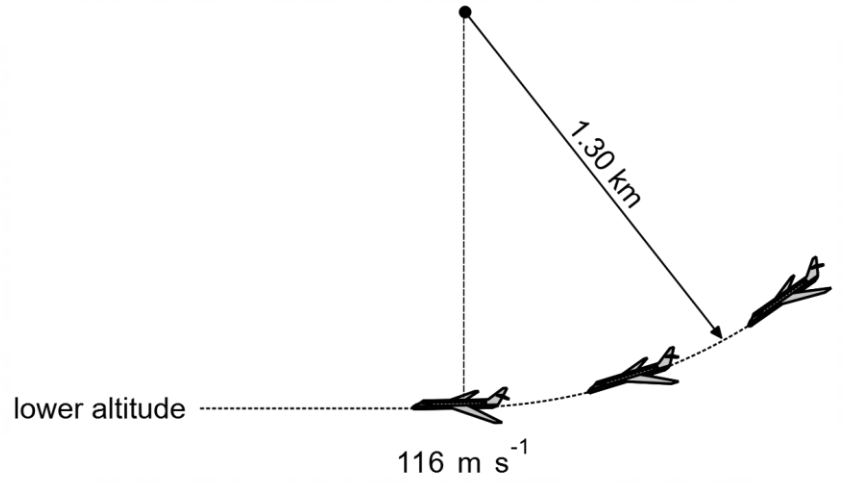
centripetal force ____________________ N

centripetal acceleration __________________ m s^{-2}

(b) Determine the angle that the plane must bank to achieve this horizontal flight. (2 marks)

angle ________________ °

As part of the descent of the plane, the plane follows a section of a vertical circular path of radius 1.30 km as shown below to a lower altitude. Note: diagram not to scale.



(c) During this descent the plane speeds up to a maximum of 116 m s^{-1} at the bottom. Determine the maximum apparent weight of the pilot during this manoeuvre? (4 marks)

max apparent weight ______________ N

Section Three: Comprehension **20% (36 marks)**

This section has two (2) questions. Answer **both** questions in the spaces provided.
Suggested working time: 40 minutes.

Question 19 **(18 marks)**

Olympic Discus Throw

The discus throw is an Olympic event which originated in the pentathlon in ancient Greece around 700 BC and has continued ever since. Early discuses were made of stone, bronze, or iron.

The aim of Olympic discus is to throw the discus as far as possible, within the allowable region. The allowable region is an angular region of 35° from the centre of the throwing circle. The throwing circle is a 2.50 m diameter circle where the thrower must always stay within (Figure 1).

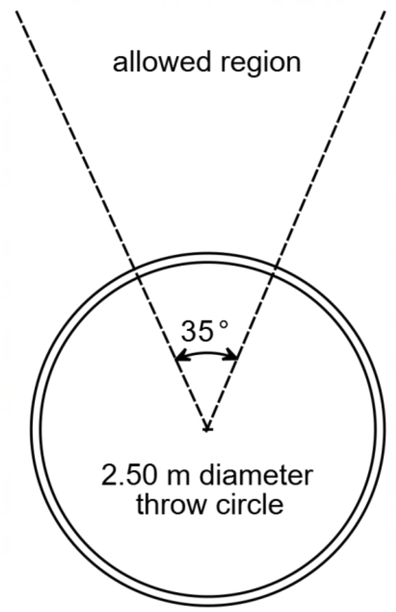


Figure 1 - Discus Throw Area

The discus itself is a round thin object, usually made of wood, hard plastic or metal, with a diameter of about 15 – 25 cm, having a mass of 1.00 kg (women) and 2.00 kg (men). Modern discuses have more of the mass located on the outer edge of the discus, rather than in the middle.

The current Olympic record for men's discus is 69.89 m (2004), and for women's discus is 72.30 m (1988). However, the longest ever recorded discus throw is 74.08 m (1986).

The thrower begins by facing away from the throw region, holds the discus in one hand and then rotates through one and a half rotations within a circular area of diameter 2.50 m (Figure 1). The thrower then spins around to gain momentum. The athlete must begin with both feet firmly on the ground, then begins to spin, first on one leg, then on the other. This builds up speed, which is translated into momentum for the discus. Finally, the thrower releases the discus into the allowed throw region. From stationary to release, the throwing action takes around one second.

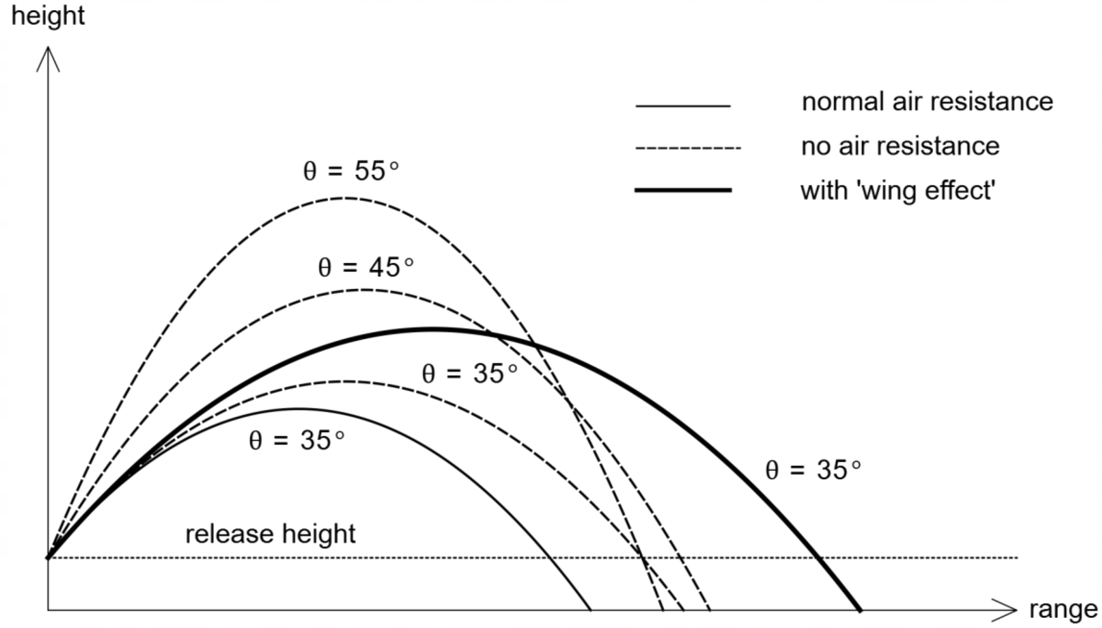


Figure 2 - Trajectory of discus for various angles

One of the unique aspects of discus is that the discus spins as it leaves the hand of the thrower causing the discus to angle upwards to catch and ride on the wind, thus giving extra lift to the discus, increasing the range of the discus. The 'angle of attack' of the discus is the angle the plane of the discus makes with the direction of motion (Figure 3). The lift force acts perpendicular to the direction of motion. The percentage increase in the range of the discus, due to this extra lift, is called the 'wing effect. The 'wing effect' can increase the range of the discus by up to 20%.

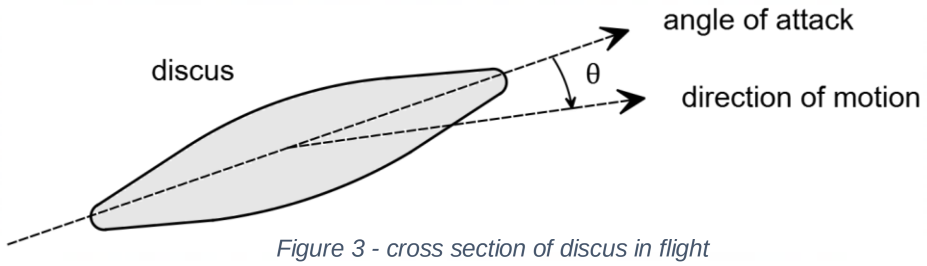


Figure 3 - cross section of discus in flight

The drag force due to air resistance always acts in the opposite direction to the motion of the discus. An increased angle of attack and increased speed will result in a higher drag force.

One of the main factors affecting the range of a discus throw is the angle of release. Figure 2 shows the path of a discus for three different angles: 35°, 45° and 55°. The dashed line indicates no air resistance, the solid line with air resistance and the bold line air resistance with the wing effect. The diagram shows the path of a discus thrown at 35° for these three scenarios: normal air resistance, no air resistance and with 'wing effect'.

The main technique of discus is to ensure maximum release speed, with just the right amount of spin, at just the right release angle. Even with a sufficient spin rate, if the angle of attack is too large the discus will have lots of lift but insufficient horizontal speed and thus "fall out of the sky".

(a) Explain how the phenomenon of 'wing effect' increases the range of a discus. Use relevant physics concepts in your explanation. (4 marks)

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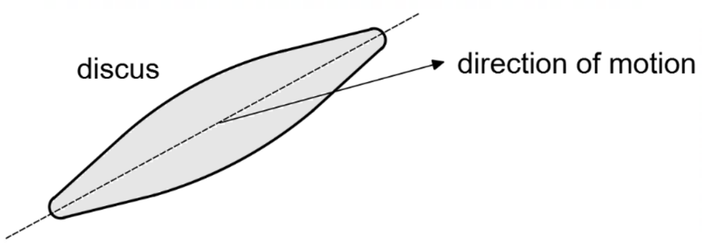
(b) A certain discus throw has the following parameters: the angle of release is 37.6°, the height of release is 1.66 m, the range of the throw was measured at 69.2 m, and the release speed was 24.0 m s^{-1}. By calculating the expected range (with no air resistance) determine the 'wing effect', as a percentage, for this throw? (6 marks)

wing effect ______________ %

(c) Estimate the maximum tension in the arm of an Olympic female discus thrower during her throw. Give your answer to an appropriate number of significant figures. Clearly state your assumptions. (4 marks)

maximum tension ________________ N

(d) The discus below is travelling upwards and has an angle of attack of 10°. On the discus below draw and label the forces acting on the discus. In the dashed box draw a vector diagram, including the net force. Assume that this discus is uniform. (4 marks)



Question 20 **(18 marks)**

Power from Wind Turbines

Wind power has been around for a while, since the late 1800s. The first recorded wind turbine is in the US in 1888, where a rich aristocrat used it to produce electricity for his mansion. Today wind farms are quite common in many countries around the world. In Australia there are currently 94 wind farms (a wind farm is a collection of large wind turbines), producing a combined power of 16 GW nationally.

The advantages of wind power are that, once the wind turbine is installed, very little input is required from the owner with relatively low operating costs. The wind turbine will spin in consistent wind, spinning the turbine inside the main housing, thus generating electricity. The use of wind is renewable and a clean source of energy.

There are, however, several disadvantages. Wind turbines are quite costly to install and must pass strict environmental criteria. A wind turbine is also dependent on consistent wind speeds to produce enough power and so the location must be carefully chosen. The visual impact (as well as noise pollution) are other factors that must be considered when positioning and designing wind farms.

Figure 4 below shows the main components of a turbine: rotors, nacelle, tower, and foundation.

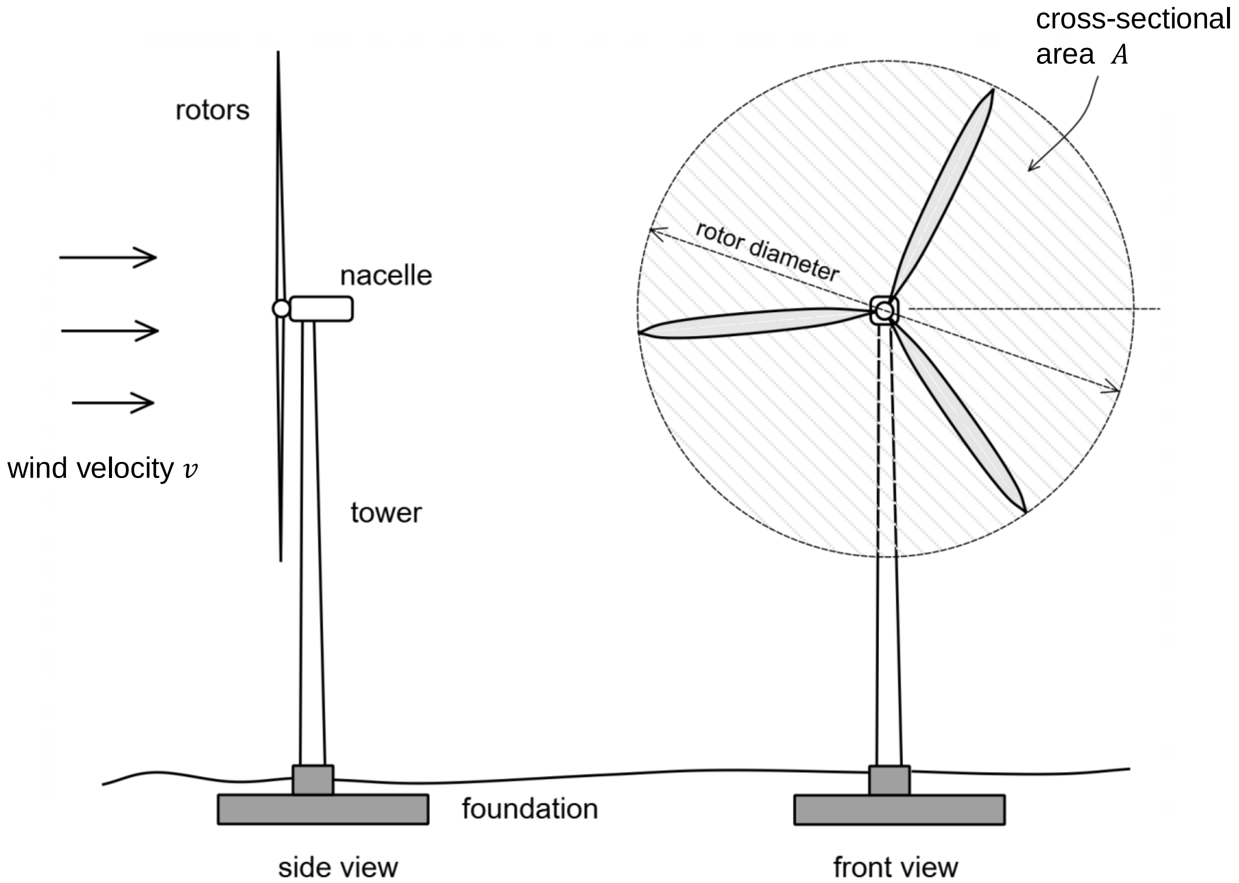


Figure 4 – main components of wind turbine

The rotors (or the blades) are responsible for catching the wind and converting the kinetic energy of the wind into rotational energy of the rotors. The rotors of turbines are also capable of spinning on their axis, angling into or out of the wind. In this way the rotors can catch more or less of the wind, depending on conditions.

See next page

The nacelle is the hub like box situated behind the main rotor blades. The nacelle contains a gearbox and generator. The purpose of the gearbox is to ensure that the generator runs at a constant rotational speed of 50 Hz, to generate power at 50 Hz. Therefore, the gearbox will adjust the output speed for the generator to ensure a smooth 50 Hz. The nacelle also houses a brake mechanism which can stop the blades in high, dangerous winds.

The tower is the main upright designed to support the entire turbine ensuring it is sufficiently supported and safely off the ground.

The foundation of the wind turbine is the large concrete footing to which the tower is fastened. The foundation is designed to support the weight of the turbines, nacelle, and tower, but also prevent the toppling or twisting of the tower due to the winds rotating the rotors.

The maximum theoretical power that can be extracted from the force of wind blowing past was found by Albert Betz in 1919 and is given by what has become known as Betz's law:

$$P_B = \frac{8}{27}\rho v^3 A$$

Where P_B is the maximum available power (W), ρ is the density of air (kg m^{-3}), v the velocity of the air (m s^{-1}) and A the total cross-sectional area of the rotating rotors exposed to the wind (m^2). Typically wind turbines only utilise about 60% – 75% of this available energy.

The amount of electrical power generated from a turbine, often referred to as "rms power" or "average power", P_{avg} is given by:

$$P_{\text{avg}} = \frac{1}{2}V_{\text{peak}}I_{\text{peak}}$$

Where V_{peak} is the maximum voltage generated and I_{peak} is the maximum current generated.

The utility factor of a wind turbine is the ratio of the average electrical power produced to available power: P_{avg}/P_B.

The most common wind turbine is the 1.50 MW turbine. The following data is a collection of information about some of the key features of this turbine:

Rotor blade diameter	78.0 m
Rated Power output	1.50 MW
Rotor assembly weight	25.0 tonnes
Nacelle weight	42.0 tonnes
Tower width at top	2.20 m

Figure 5 shows the nacelle and rotor assembly components, with their centre of masses located 1.80 m and 3.20 m respectively from the centreline of the tower. Point X represents the centre of gravity of the entire top section (i.e., the nacelle and the rotor assembly).

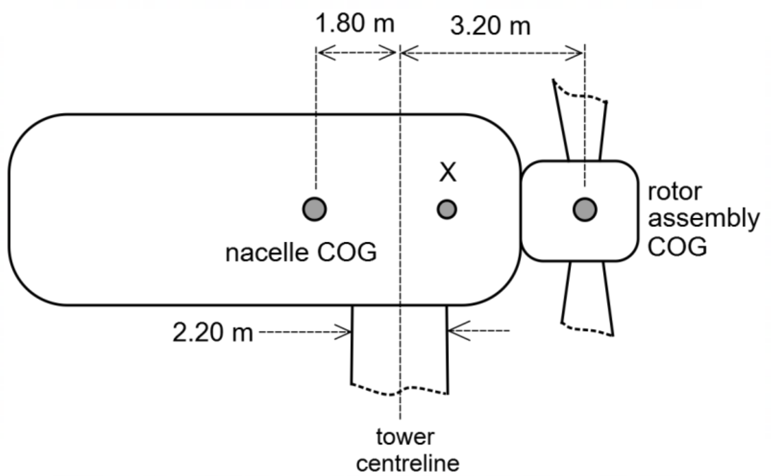


Figure 5 – nacelle and rotor assembly

(a) List one economic advantage and one environmental disadvantage of wind turbines. (2 marks)

Economic Advantage ____

Environmental disadvantage ____

(b) The peak current flowing in a 1.5 MW turbine is 105 A, the strength of the magnetic field is 2.25 T, the coils consist of 315 turns of wire and are formed in a 30.0 cm by 42.0 cm rectangle. Using this information, show that the average power of this turbine is approximately 1.5 MW. (5 marks)

(c) Using Betz's law, calculate the maximum power which can be extracted from a 1.5 MW wind turbine in winds speeds of 40.0 km h^{-1} (the density of air is 1.225 kg m^{-3}). (4 marks)

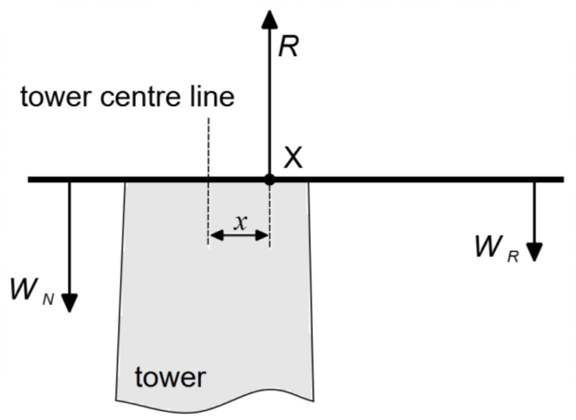
power ________________ MW

(d) Using your answer to part (b) and (c) calculate the utility factor of a 1.5 MW wind turbine. (Note: if you didn't calculate part (b) and/or (c) you may use an average power of 1.5 MW and an available power of 2.4 MW). (1 mark)

utility factor ____________________

(e) A simplified free-body diagram of the forces acting on the nacelle and rotor assembly is shown below. By taking torques about a suitable point, calculate the location of point X in relation to the centre line of the tower. Explain what this means in relation to the stability of the assembly. Assume that the reaction force *R* acts through point X. (6 marks)

Note: W_N = weight of nacelle and W_R = weight of rotor.



distance x ____________________ m

Explanation

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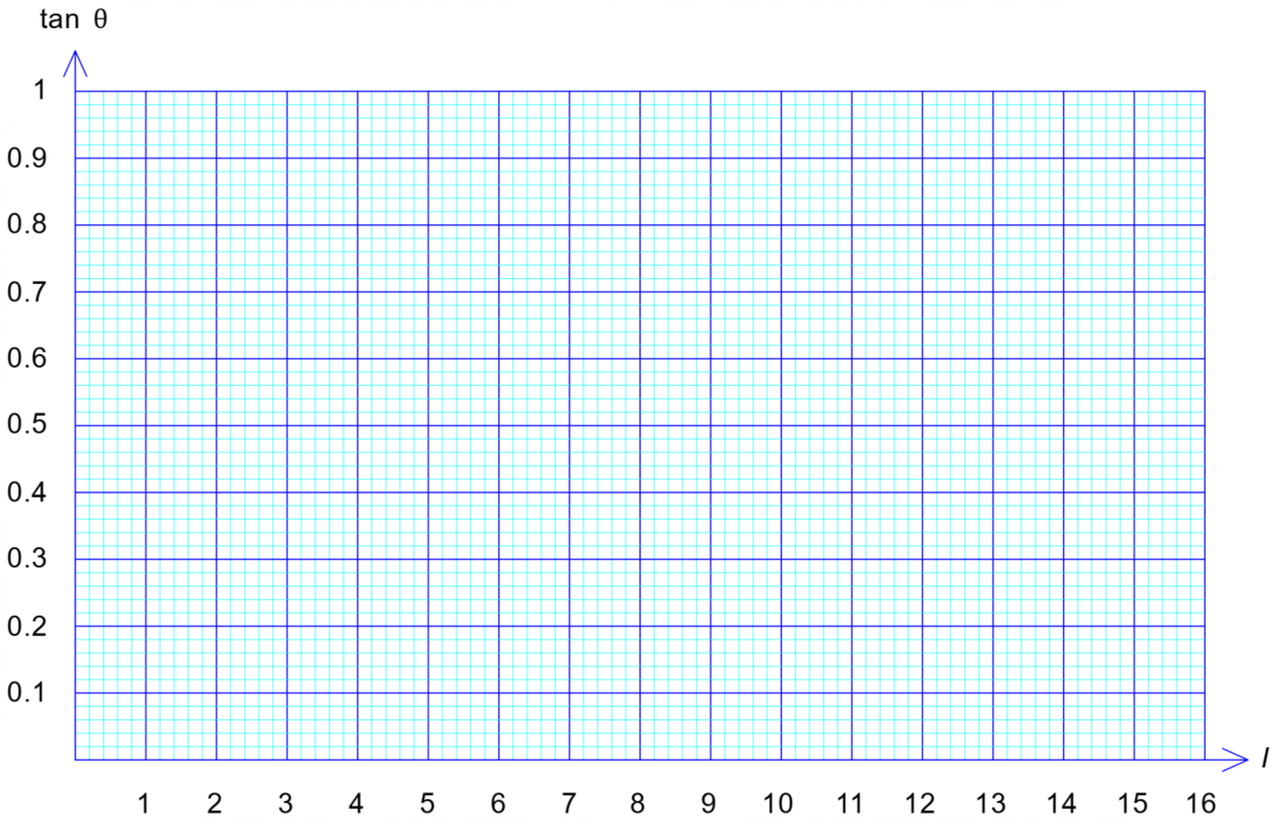
End of Questions

Spare Graphs for Question 12 and 13



Additional working space

Question number(s): ……………………

ACKNOWLEDGEMENTS

Question 19 Information about Discus Throw adapted from Wikipedia contributors. (2021, October 18). Discus throw. In Wikipedia, The Free Encyclopedia. Retrieved 12:41, September 2, 2021, from https://en.wikipedia.org/wiki/Discus_throw

Question 20 Information about wind turbines taken from Wikipedia contributors. (2021, September 1). Wind turbine. In Wikipedia, The Free Encyclopedia. Retrieved, September 11, 2021, from https://en.wikipedia.org/wiki/Wind_turbine

Information about Betz's law taken from Wikipedia contributors. (2021, March 9). Betz's law. In Wikipedia, The Free Encyclopedia. Retrieved September 11, 2021, from https://en.wikipedia.org/wiki/Betz%27s_law

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