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| 8: Mechanics 1Scalars, Vectors and Moments |
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| Paper 1 |  |
| 1: Particles 1Atomic Structure and the SNF | 1. Nature of scalars and vectors.
2. Examples should include: velocity/speed, mass, force/weight, acceleration, displacement/distance.
3. Addition of vectors by calculation or scale drawing.
4. Calculations will be limited to two vectors at right angles. Scale drawings may involve vectors at angles other than 90°.
5. Resolution of vectors into two components at right angles to each other.
6. Examples should include components of forces along and perpendicular to an inclined plane.
7. Problems may be solved either by the use of resolved forces or the use of a closed triangle.
8. Conditions for equilibrium for two or three coplanar forces acting at a point. Appreciation of the meaning of equilibrium in the context of an object at rest or moving with constant velocity.
9. Moment of a force about a point.
10. Moment defined as force × perpendicular distance from the point to the line of action of the force.
11. Couple as a pair of equal and opposite coplanar forces.
12. Moment of couple defined as force × perpendicular distance between the lines of action of the forces.
13. Principle of moments.
14. Centre of mass.
15. Knowledge that the position of the centre of mass of uniform regular solid is at its centre.
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| 2: Particles 2Particle Classification |
| 3: Particles 3Particle Interaction |
| 4: QuantumPhotoelectric, Energy Levels and WPD |
| 5: Waves 1Wave Basics and Stationary Waves |
| 6: Waves 2Interference and Diffraction |
| 7: Waves 3Refraction and Fibre Optics |
| 8: Mechanics 1Scalars, Vectors and Moments |
| 9: Mechanics 2Motion and Newton’s Laws |
| 10: Mechanics 3Momentum and Energy |
| 11: MaterialsHooke’s Law and the Young Modulus |
| 12: Electricity 1Resistivity and Superconductivity |
| 13: Electricity 2Series, Parallel and Potential Dividers |
| 14: Electricity 3Energy, EMF and Internal Resistance |
| 15: Further Mechanics 1Circular Motion |
| 16: Further Mechanics 2Simple Harmonic Motion |

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| **Monday: Scalars and Vectors Notes**What is the difference between a scalar quantity and a vector quantity?………………………………………………………………….…………….……………………………………………………….………………..………………………………………………………………….…………….……………………………………………………….………………..……………………………………………………………………….……….………………………………………………………………………...Are the following quantities scalars or vectors? Acceleration ……….….…. Displacement ………………. Distance ………………. Energy ………………. Force ………….….. Mass ………………. Momentum ………………. Power ………………. Speed …………..…. Time ………………. Velocity ………………. Weight ……………….Adding VectorsTo find the resultant vector of **a** + **b** we draw vector **a** then draw vector **b** from the end of **a**. The resultant is the line that connects the start of **a** and the end of **b**.Calculate the size and direction of the resultant force when the following vectors are added together:

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| --- | --- | --- |
|  | d + i | k + g |
|  |  |  |

Draw the negative vectors for **a**, **b** and **c**.

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Calculate the size and direction of the resultant forces when the following vectors are added together:

|  |  |  |
| --- | --- | --- |
| a + b | c – b  | a + b – c |
|  |  |  |

If the forces in the diagrams above were acting on an object what would the last combination mean?………………………………………………………………….…………….……………………………………………………….………………..………………………………………………………………….…………….……………………………………………………….………………..A vector can be broken down into its horizontal and vertical components. This is called resolving a vector.Resolving is the opposite to the first adding vectors activity that we did in the last lesson.Resolve these vectors into their horizontal and vertical components (they are not drawn to scale).

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| Horizontal …………………….Vertical ……………………. | Horizontal …………………….Vertical ……………………. | Horizontal …………………….Vertical ……………………. | Horizontal …………………….Vertical ……………………. |

What is meant by the term ‘equilibrium’?………………………………………………………………….…………….……………………………………………………….………………..………………………………………………………………….…………….……………………………………………………….………………..……………………………………………………………………….……….………………………………………………………………………...How can we tell that equilibrium is reached by scale diagram?………………………………………………………………….…………….……………………………………………………….………………..……………………………………………………………………….……….………………………………………………………………………...

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| The conditions needed for finding equilibrium by resolving vectors can be summarised as: | = | = |

The diagram shows a 250 kg iron ball being used on a demolition site. The ball is suspended from a cable at point A, and is pulled into the position shown by a rope that is kept horizontal. The tension in the rope is 1200 N.In the position shown the ball is in equilibrium.What balances the force of the rope on the ball?………………………………………………………………...…………………………………….What balances the weight of the ball?………………………………………………………………...…………………………………….

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| Calculate the magnitude of the vertical component of the tension in the cable. | Calculate the magnitude of the horizontal component of the tension in the cable. |
| Calculate the magnitude of the tension in the cable. | Calculate the angle the cable makes to the vertical. |

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**Tuesday: Vectors and Moments Exam Questions**

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| **Q25(ai)** State **two** vector quantities.vector quantity 1 ..........................................................................................................vector quantity 2 ..........................................................................................................**Q25(aii)** State **two** scalar quantities.scalar quantity 1 ..........................................................................................................scalar quantity 2 .......................................................................................................... **(2)****Q25(b)** The helicopter shown in **Figure 1a** is moving horizontally through still air. The lift force from the helicopter’s blades is labelled **A**.**Figure 1a Figure 1b****Q25(bi)** Name the two forces **B** and **C** that also act on the helicopter.**B** ...........................................................................................................**C** ........................................................................................................... **(2)****Q25(bii)** The force vectors are also shown arranged as a triangle in **Figure 1b**. State and explain how **Figure 1b** shows that the helicopter is moving at a constant velocity......................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................... **(2)****Q25(c)** The lift force, **A**, is 9.5 kN and acts at an angle of 74° to the horizontal.Calculate the weight of the helicopter. Give your answer to an appropriate number of significant figures.                                                             answer = ..................................... N **(3)****(Total 9 marks)****Q36.** It is said that Archimedes used huge levers to sink Roman ships invading the city of Syracuse. A possible system is shown in the following figure where a rope is hooked on to the front of the ship and the lever is pulled by several men. **Q36(ai)** Calculate the mass of the ship if its weight was 3.4 × 104 N.   mass ......................................... kg **(1)****Q36(aii)** Calculate the moment of the ship’s weight about point **P**. State an appropriate unit for your answer.   moment ......................................... unit .................... **(2)****Q36(aiii)** Calculate the minimum vertical force, ***T***, required to start to raise the front of the ship. Assume the ship pivots about point **P**.   minimum vertical force ......................................... N **(2)****Q36(aiv)** Calculate the minimum force, ***F***, that must be exerted to start to raise the front of the ship.   force ......................................... N **(3)****(Total 8 marks)** |

**Wednesday: Using Moments Extended Writing**

Here is an example of an application of the principle of moments. The device, pictured below, consists of beam suspended from one point and is used to find the mass of objects.

Describe and explain how the device would be operated. Your answer should include:

* An account of how the device would be used to find the mass of an object
* An explanation of the principles of moments and how they apply in this situation
* An explanation of how it could be recalibrated to measure the value of greater masses
* Details of how you could improve the precision of the measurements taken.

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**Wednesday: Scalars, Vectors and Moments Definitions**

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| Weight | The force of gravity acting on an object. |
| Resolving | The process of separating a vector into its horizontal and vertical components. |
| Centre of Mass | The point at which all of the mass of an object can be thought to be concentrated. |
| Scalar | A quantity having a magnitude but no direction. |
| Perpendicular | To calculate a moment the force and distance must be this. |
| Changing | If the forces acting on an object are not in equilibrium the speed of the object will be this. |
| Velocity | An example of a vector quantity. |
| Resultant | The name for the single force that replaces several forces that are acting on the same object. |
| Moment | The turning effect of a force |
| Cos | If we are given the adjacent length and the hypotenuse, to calculate the angle we would use… |
| Vector | A quantity with a magnitude and a direction. |
| Equal | If an object isn’t toppling over the clockwise and anti-clockwise moments are this. |
| Line of Action | The direction along which a force is acting. |
| Sin  | If we are given the opposite length and the hypotenuse, to calculate the angle we would use… |
| Equilibrium | This is reached if the forces acting form a closed triangle when drawn one after the other. |
| Couple | A pair of equal and opposite coplanar forces. |
| Closed Triangle | If three forces acting on an object are in equilibrium they will form this. |
| Pythagoras  | We would use this to calculate the unknown side of a right angled triangle. |
| Tan | If we are given the opposite and adjacent lengths, to calculate the angle we would use… |
| Distance | An example of a scalar quantity. |
| Mass | The amount of matter than an object in made from. |
| Constant | If the forces acting on an object are in equilibrium the speed of the object will be this. |

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| --- | --- | --- | --- |
| Centre of Mass | Changing | Closed Triangle | Constant |
| Cos | Couple | Distance | Equal |
| Equilibrium | Line of Action | Mass | Moment |
| Perpendicular | Pythagoras  | Resolving | Resultant |
| Scalar | Sin  | Tan | Vector |
| Velocity | Weight |  |  |

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| **Thursday: Moments Notes**Define ‘the moment of a force about a point’. ………………………………………………………………….…………….……………………………………………………….………………..………………………………………………………………….…………….……………………………………………………….………………..……………………………………………………………………….……….…………………………….…………………………………………..A moment can be calculated using the following equation:$$M=Fd$$Symbol $M$ Quantity …………………………………………………………………………………………… Units ………………………Symbol $F$ Quantity …………………………………………………………………………………………… Units ………………………Symbol $d$ Quantity ……………………………………………………………………………………………  …………………………………………………………………………………………… Units ………………………Complete these tables by calculating the missing values.

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| --- | --- | --- | --- | --- | --- | --- |
| *M* | *F* | *d* |  | *M* | *F* | *d* |
|  | 45 | 0.1 |  |  | 900 | 0.2 |
| 360 |  | 1.2 |  | 480 |  | 0.6 |
| 48 | 8 |  |  | 75 | 250 |  |

Use this diagram to help you explain what a ‘couple’ is and how it is calculated.………………………………………………………………….…………….………………………………………………………………………………………….…………….………………………………………………………………………………………….…………….………………………………………………………………………………………….…………….………………………Levers are simple machines that use the concept of moments. In a lever system what is the effort? …………………………….………………….……………….…………………………….….………….In a lever system what is the load? …………………………….………….….…………….………………………………………………..…Explain how levers work …………………………………….…………….……………………………………………………….………………..………………………………………………………………….…………….……………………………………………………….………………..What is meant by the principle of moments?………………………………………………………………….…………….……………………………………………………….………………..………………………………………………………………….…………….……………………………………………………….………………..……………………………………………………………………….……….…………………………….…………………………………………..Complete this table by calculating the missing values for a balanced see-saw.

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| --- | --- |
| Anticlockwise | Clockwise |
| *F* | *d* | *M* | *M* | *F* | *d* |
| 250 | 0.3 |  |  |  | 1.2 |
| 300 | 3.2 |  |  | 750 |  |
|  | 2.4 |  |  | 6000 | 6.4 |
| 400 |  |  |  | 160 | 1.75 |

Calculate the mass of the person if the seesaw is balanced.Explain what is meant by the ‘centre of mass’ of an object.………………………………………………………………….…………….……………………………………………………….………………..……………………………………………………………………….……….………………………………………………………….……………..Where is the centre of mass of a regular shape?……………………………………………………………………….……….………………………………………………………….……………..Describe how you could find the centre of mass of an irregular shaped object.……………………………………………………………………….……….………………..………………………………………………………………………….……….………..………………………………………………………………………………….……….………..………………………………………………………………………………….……….……..…………………………………………………………………………………….……….……..……………Describe when a tilted object will topple over …………….…………….……………………………………………………….………………..……………………………………………………………………….……….………………………………………………………….……………..Why would a tilted object topple over? ………...………….…………….……………………………………………………….………………..……………………………………………………………………….……….………………………………………………………….……………..Describe the two ways to increase the stability of an object.1.……………………………………………………………….…………….……………………………………………………….………………..2.…………………………………………………………………….……….………………………………………………………….……………..Conditions needed for equilibrium:

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**Double Pivot Situations**1) Pick one of the pivots.2) The force acting at that pivot doesn’t have a turning effect about that pivot.3) Use the equilibrium conditions above.Calculate P and Q. |

**Friday: Moments Exam Questions**

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| **Q35.**  The figure below shows a motorcycle and rider. The motorcycle is in contact with the road at **A** and **B**. The motorcycle has a weight of 1100 N and the rider’s weight is 780 N.**Q35(a)**  State the Principle of Moments.............................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................. **(2)****Q35(b)**  Calculate the moment of the rider’s weight about **B**. Give an appropriate unit.   answer = .......................................... **(2)****Q35(c)**  By taking the moments about **B**, calculate the vertical force that the road exerts on the front tyre at **A**. State your answer to an appropriate number of significant figures.     answer = ................................. N **(4)****Q35(d)**  Calculate the vertical force that the road exerts on the rear tyre at **B**.   answer = ................................. N **(1)****Q35(e)**  The maximum power of the motorcycle is 7.5 kW and it has a maximum speed of 26 m s–1, when travelling on a level road. Calculate the total horizontal resistive force for this speed.    answer = ................................. N **(2)****(Total 11 marks)****Q36.** The figure below shows an aircraft designed to take off and land vertically and also to hover without horizontal movement. In order to achieve this, upward lift is produced by directing the jet engine outlet downwards. The engine also drives a vertical lift fan near the front of the aircraft. The weight of the aircraft is 180 kN. The distance between the lift fan and the centre of mass is 4.6 m and the distance between the jet engine outlet and the centre of mass is 2.8 m.**Q36(ai)** Calculate the moment caused by the weight of the aircraft about the point **X**.                                                            answer = .............................. Nm **(2)****Q36(aii)** By taking moments about **X**, calculate the lift fan thrust if the aircraft is to remain horizontal when hovering.                                                                answer = .............................. N **(3)****Q36(aiii)** Calculate the engine thrust in the figure above.                                                                answer = .............................. N **(1)****Q36(b)** Having taken off vertically, the jet engine outlet is turned so that the engine thrust acts horizontally. The aircraft accelerates horizontally to a maximum velocity. The forward thrust produced by the jet is 155 kN. The weight of the aircraft is 180 kN.**Q36(bi)** When the resultant horizontal force is 155 kN, calculate the horizontal acceleration of the aircraft.                                                          answer = .............................. ms–2 **(2)****Q36(bii)** State and explain **one** characteristic of the aircraft that limits its maximum horizontal velocity....................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................... **(1)** **(Total 10 marks)** |

**Saturday: Scalars, Vectors and Moments Checklist**

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| # |  | I can… |  ☹ |  😐 |  ☺ |
| 1 |  | Define the term scalar. |  |  |  |
| 2 |  | Recall examples of scalar quantities. |  |  |  |
| 3 |  | Define the term vector. |  |  |  |
| 4 |  | Recall examples of vector quantities. |  |  |  |
| 5 |  | Calculate the resultant force of two vectors at 90 degrees to each other using Pythagoras.  |  |  |  |
| 6 |  | Calculate the resultant force of two vectors at 90 degrees to each other using a scale diagram. |  |  |  |
| 7 |  | Calculate the resultant force of two vectors not at 90 degrees to each other using a scale diagram. |  |  |  |
| 8 |  | Measure the unknown angle from a scale diagram. |  |  |  |
| 9 |  | Calculate the unknown angle using trigonometry. |  |  |  |
| 10 |  | Calculate the horizontal component of a vector (resolve). |  |  |  |
| 11 |  | Calculate the vertical component of a vector (resolve). |  |  |  |
| 12 |  | Calculate the component of a vector parallel to an inclined plane. |  |  |  |
| 13 |  | Calculate the component of a vector perpendicular to an inclined plane. |  |  |  |
| 14 |  | Explain what is meant by the term equilibrium. |  |  |  |
| 15 |  | Explain how you know if equilibrium is reached by scale diagram. |  |  |  |
| 16 |  | Explain how you know if equilibrium is reached by resolving vectors. |  |  |  |
| 17 |  | Calculate the unknown magnitude of a vector in an equilibrium situation. |  |  |  |
| 18 |  | Calculate the unknown angle of a vector in an equilibrium situation. |  |  |  |
| 19 |  | Describe the connection between equilibrium and speed/velocity. |  |  |  |
| 20 |  | Measure a force using a force-meter/newton-meter. |  |  |  |
| 21 |  | Sketch a free-body force diagram. |  |  |  |
| 22 |  | Label the forces on a free-body force diagram. |  |  |  |
| 23 |  | Define the moment of a force about a point. |  |  |  |
| 24 |  | Calculate the moment of a force when perpendicular distance is given (or calculated). |  |  |  |
| 25 |  | Recall or deduce the units of moment. |  |  |  |
| 26 |  | Rearrange the moment equation to find the unknown. |  |  |  |
| 27 |  | Explain what is meant by the line of action of a force. |  |  |  |
| 28 |  | Calculate the perpendicular distance from the pivot to the line of action of a force. |  |  |  |
| 29 |  | Explain how levers work. |  |  |  |
| 30 |  | Describe applications of levers. |  |  |  |
| 31 |  | Explain applications of levers. |  |  |  |
| 32 |  | Define the moment of a couple. |  |  |  |
| 33 |  | Calculate the moment of a couple. |  |  |  |
| 34 |  | Explain what is meant by the principle of moments. |  |  |  |
| 35 |  | Calculate the unknown in a simple balancing situation. |  |  |  |
| 36 |  | Calculate the unknown (force) in a double pivot situation. |  |  |  |
| 37 |  | Explain what is meant by the term centre of mass of an object. |  |  |  |
| 38 |  | Describe how to find the position of the centre of mass of a uniform regular solid. |  |  |  |
| 39 |  | Describe how to find the position of the centre of mass of an irregular solid. |  |  |  |
| 40 |  | Describe when a tilted object will topple over. |  |  |  |
| 41 |  | Explain why a tilted object will topple over. |  |  |  |
| 42 |  | Describe ways to increase the stability of an object. |  |  |  |