|  |
| --- |
| 10: Mechanics 3Momentum and Energy |
|  |
| Paper 1 |  |
| 1: Particles 1Atomic Structure and the SNF | 1. *momentum = mass × velocity*
2. Conservation of linear momentum.
3. Principle applied quantitatively to problems in one dimension.
4. Force as the rate of change of momentum,
5. Impulse = change in momentum
6. , where *F* is constant.
7. Significance of the area under a force–time graph.
8. Quantitative questions may be set on forces that vary with time. Impact forces are related to contact times (eg kicking a football, crumple zones, packaging).
9. Elastic and inelastic collisions; explosions.
10. Appreciation of momentum conservation issues in the context of ethical transport design.
11. Energy transferred,
12. *rate of doing work = rate of energy transfer*,
13. Quantitative questions may be set on variable forces.
14. Significance of the area under a force–displacement graph.
15. Efficiency can be expressed as a percentage.
16. Principle of conservation of energy.
17. and
18. Quantitative and qualitative application of energy conservation to examples involving gravitational potential energy, kinetic energy, and work done against resistive forces.

 |
| 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 |

|  |  |  |
| --- | --- | --- |
| **Monday: Momentum and Impulse Notes**The momentum of an object is given by the following equation:Symbol Quantity …………………………………………………………………………………………… Units ………………………Symbol Quantity …………………………………………………………………………………………… Units ………………………Symbol Quantity …………………………………………………………………………………………… Units ………………………What is meant by the conservation of momentum?………………………………………………………………….…………….……………………………………………………….………………..……………………………………………………………………….……….…………………………………………………….…………………..………………………………………………………………………..……….………………………………………………………………………..When does the conservation of momentum apply?……………………………………………………………………….……….…………………………………………………….…………………..………………………………………………………………………..……….………………………………………………………………………..Explain what is meant by an elastic collision.………………………………………………………………….…………….……………………………………………………….………………..……………………………………………………………………….……….…………………………………………………….…………………..Explain what is meant by an inelastic collision.………………………………………………………………….…………….……………………………………………………….………………..……………………………………………………………………….……….…………………………………………………….…………………..The diagram shows a car and a van, just before and just after the car collided with the van.https://app.doublestruck.eu/content/AG_PHS/HTML/Q/Q13WY2H06_files/img01.png Calculate the velocity of the van after the collision.The larger car collided with the stationary car in front, joining the two cars together. https://app.doublestruck.eu/content/AG_PHS/HTML/Q/Q15S2H04_files/img02.png Calculate the velocity of the two joined cars immediately after the collision.Force can be connected to momentum by the equation:Symbol Quantity …………………………………………………………………………………………… Units ………………………Symbol Quantity …………………………………………………………………………………………… Units ………………………Symbol Quantity …………………………………………………………………………………………… Units ………………………Symbol Quantity …………………………………………………………………………………………… Units ………………………What happens to the size of the force if the time taken to change momentum:A. increases? ……………………………………………………. B. decreases? …………………………………………………….C. doubles? ……………………………………………………. D. halves? …………………………………………………….What is an impulse?…………………………………………………………………………..…….………………………………………………………………………..………………………………………………………………………..……….………………………………………………………………………..What can an impulse cause?…………………………………………………………………………..…….………………………………………………………………………..………………………………………………………………………..……….………………………………………………………………………..Impulse and momentum are connected by the following equation:Symbol Quantity ………………………………………………………………………………………… Units ………………………Symbol Quantity ………………………………………………………………………………………… Units ………………………Complete this table by calculating the missing values.What happens to the change in momentum if the time that the force is applied for:A. increases? ……………………………………………………. B. decreases? …………………………………………………….C. doubles? ……………………………………………………. D. halves? …………………………………………………….What does the area under a force-time graph represent?………………………………………………………………………..……….………………………………………………………………………..

|  |  |
| --- | --- |
| Calculate the final velocity of an object of mass 4kg that was initially stationary before the force acted on it.https://app.doublestruck.eu/content/AA_PA/HTML/Q/QS134A04_files/img01.png | Calculate the final velocity of an object of mass 2kg that was initially travelling with velocity -2m/s before the force acted on it.https://app.doublestruck.eu/content/AA_PHYS/HTML/Q/QS164A02_files/img01.png |

 |

**Tuesday: Momentum Exam Questions**

|  |
| --- |
| **Q45(a)** State, in words, the relationship between the force acting on a body and the momentum of the body....................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................... **(1)****Q45(b)** A container rests on a top-pan balance, which measures mass in kg. A funnel above the container holds some sand. The sand falls at a constant rate of 0.300 kg s–1 into the container, having fallen through an average vertical height of 1.60 m.This arrangement is shown in the figure below.**Q45(bi)** Show that the velocity of the sand as it lands in the container is 5.6 ms–1.    **(1)****Q45(bii)** Calculate the magnitude of the momentum of the sand that lands in the container in each second.                                                             answer = .............................. Ns **(1)****Q45(biii)** The mass of the container is 0.650 kg. Show that the reading of the balance, 10.0 s after the sand starts landing continuously in the container, will be 3.82 kg. You may assume that the sand comes to rest without rebounding when it lands in the container.      **(3)****(Total 6 marks)****Q46(a)**  State, in words, how the force acting on a body is related to the change in momentum of the body..................................................................................................................................................................................................................................................................................................................................................................................................... **(1)****Q46(b)**  A football of mass 0.42 kg is moving horizontally at 10 m s–1 towards a footballer’s boot, which then kicks it. The figure below shows how the force between the boot and the ball varies with time while they are in contact.**Q46(bi)** What is the significance of the area enclosed by the line on a force–time graph and the time axis when a force acts on a body for a short time?.................................................................................................................................................................................................. **(1)****Q46(bii)** Estimate the impulse that acts on the ball, stating an appropriate unit.    answer = .................................................. **(4)****Q46(biii)** Calculate the speed of the ball after it has been kicked, assuming that it returns along the same horizontal line it followed when approaching the boot. Express your answer to an appropriate number of significant figures.     answer = .......................................m s–1 **(4)****Q46(c)** Discuss the consequences if the ball had approached the boot at a higher speed but still received the same impulse............................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................. **(3)** **(Total 13 marks)** |

**Wednesday: Bouncing Extended Writing**



The diagram shows a gymnast trampolining with her lowest and highest positions shown. On her next jump she decided to reach a height above position B. Describe and explain how this is achieved, your answer should include:

* The energy transformations occurring as she travels to and from B
* The work done as she travels between A and B
* How it is possible to reach a height above B
* The consequences of reaching this height
* An example of where Newton’s laws apply.

...................................................................................................................

...................................................................................................................

..................................................................................................................................................................................................

..................................................................................................................................................................................................

..................................................................................................................................................................................................

..................................................................................................................................................................................................

..................................................................................................................................................................................................

..................................................................................................................................................................................................

..................................................................................................................................................................................................

..................................................................................................................................................................................................

..................................................................................................................................................................................................

..................................................................................................................................................................................................

..................................................................................................................................................................................................

..................................................................................................................................................................................................

..................................................................................................................................................................................................

..................................................................................................................................................................................................

..................................................................................................................................................................................................

..................................................................................................................................................................................................

..................................................................................................................................................................................................

..................................................................................................................................................................................................

..................................................................................................................................................................................................

..................................................................................................................................................................................................

..................................................................................................................................................................................................

..................................................................................................................................................................................................

..................................................................................................................................................................................................

..................................................................................................................................................................................................

..................................................................................................................................................................................................

..................................................................................................................................................................................................

..................................................................................................................................................................................................

**Wednesday: Momentum and Energy Definitions**

|  |  |
| --- | --- |
| Air Resistance | A drag force that increases as speed does. |
| Work Done | On a force-distance graph the area under the graph represents … |
| Kinetic | A pendulum has its maximum value of this energy at the bottom of its swing. |
| Inelastic | A collision where momentum is conserved but kinetic energy isn’t. |
| Gravity | Work is done against this when an object is lifted into the air. |
| Momentum | The product of an objects mass and velocity. |
| Percentages | Efficiencies can be represented as a number less than 1 or one of these. |
| Lower | If a force acts over a shorter time the change in momentum will be… |
| Impulse | A force, F, acting for a time, t. |
| Gravitational Potential | A projectile has its maximum value of this energy at the top of its flight. |
| Efficiency | A measure of how much energy is transformed/transferred in the desired way. |
| Rate | Another term for ‘per second’. |
| Friction | Work is done against this when an object is dragged across the floor. |
| Work | When energy is transferred we say that this has been done. |
| Explosion | The momentum before is zero, one object is projected forwards and the other backwards. |
| Change in Momentum | An impulse causes this. |
| Power | The rate of energy transfer. |
| Elastic | A collision where kinetic energy and momentum are conserved. |
| Warms It | Wasted energy does this to the surroundings. |
| Conserved | If the momentum does not change it can be said to be this. |
| Higher | If the change in momentum happens over a shorter time the force experienced will be… |
| Impulse | On a force-time graph the area under the graph represents … |

|  |  |  |  |
| --- | --- | --- | --- |
| Air Resistance | Change in Momentum | Conserved | Efficiency |
| Elastic | Explosion | Friction | Gravitational Potential |
| Gravity | Higher | Impulse | Impulse |
| Inelastic | Kinetic | Lower | Momentum |
| Percentages | Power | Rate | Warms It |
| Work | Work Done |  |  |

|  |
| --- |
| **Thursday: Work, Energy, Power and Efficiency Notes**When a force acts over a distance work is done, this also means that ……………………………………..…………………………………Work done can be calculated using the following equation:Symbol Quantity …………………………………………………………………………………………… Units ………………………Symbol Quantity …………………………………………………………………………………………… Units ………………………Symbol Quantity …………………………………………………………………………………………… Units ………………………The above equation can only be used when the distance moved and the force are in the same direction.If the force and distance moved are at an angle of *θ* from each other we must use the component of the force that is in the same direction as the force (resolve the force).  The equation for calculating work done becomes:How can work done be calculated from a force-displacement graph?…………………………………………………………………………..…….………………………………………………………………………..What is work done against when an object is:A) pushed across the floor? ………………………………………………………………………………………………………………………...B) lifted up from the floor? ………………………………………………………………………………………...………………………………...C) falling to the floor? ……………………………………………………………………………………………………………………….............What is meant by the term ‘power’?.1………………………………………………………………………..…….…………………………………………………………………………2……………………………………………………………………..……….…………………………………………………………………………What does a high power mean?…………………………………………………………………………..…….………………………………………………………………………..………………………………………………………………………..……….………………………………………………………………………..Power can be calculated using the following equations:Symbol Quantity …………………………………………………………………………………………… Units ………………………Symbol Quantity …………………………………………………………………………………………… Units ………………………Symbol Quantity …………………………………………………………………………………………… Units ………………………Symbol Quantity …………………………………………………………………………………………… Units ………………………Symbol Quantity …………………………………………………………………………………………… Units ………………………What is meant by the ‘conservation of energy’?………………………………………………………………….…………….……………………………………………………….………………..……………………………………………………………………….……….………………………………………………………………………...The kinetic energy of an object is given by the following equation:Symbol Quantity …………………………………………………………………………………………… Units ………………………Symbol Quantity …………………………………………………………………………………………… Units ………………………Symbol Quantity …………………………………………………………………………………………… Units ………………………The gravitational potential energy is given by the following equation:Symbol Quantity …………………………………………………………………………………………… Units ………………………Symbol Quantity …………………………………………………………………………………………… Units ………………………Symbol Quantity …………………………………………………………………………………………… Units ………………………Symbol Quantity …………………………………………………………………………………………… Units ………………………Calculate the maximum height that the bike could reach if the cyclist stopped pedalling at the bottom of the ramp. Why is this the *maximum* height and might not be reached?…………………………………………………………………………..…….………………………………………………………………………..………………………………………………………………………..……….………………………………………………………………………..Calculate the maximum speed that the person could reach at the bottom of the slide.Why is this the *maximum* speed and might not be reached?…………………………………………………………………………..…….………………………………………………………………………..………………………………………………………………………..……….………………………………………………………………………..Efficiency is given by the following equation:What is meant by a high or low efficiency?…………………………………………………………………………..…….………………………………………………………………………..………………………………………………………………………..……….……………………………………………………………………….. |

**Friday: Work, Energy and Power Exam Questions**

|  |
| --- |
| **Q47.** Sail systems are being developed to reduce the running costs of cargo ships. The sail and ship’s engines work together to power the ship. One of these sails is shown in the figure below pulling at an angle of 40° to the horizontal.**Q47(a)** The average tension in the cable is 170 kN.Show that, when the ship travels 1.0 km, the work done by the sail on the ship is 1.3 × 108 J. **(2)****Q47(b)** With the sail and the engines operating, the ship is travelling at a steady speed of 7.0 ms–1.**Q47(bi)** Calculate the power developed by the sail.                                                           answer = ................................. W **(2)****Q47(bii)** Calculate the percentage of the ship’s power requirement that is provided by the wind when the ship is travelling at this speed. The power output of the engines is 2.1 MW.                                                             answer = .................................% **(2)****Q47(c)** The angle of the cable to the horizontal is one of the factors that affects the horizontal force exerted by the sail on the ship. State **two** other factors that would affect this force.Factor 1 ..........................................................................................................................................Factor 2 .......................................................................................................................................... **(2)****(Total 8 marks)****Q48.** A snowboarder slides down a slope, as shown in the diagram below. Between **B** and **C** her acceleration is uniform.**Q48(a)** The snowboarder travels 1.5 m from B to C in a time of 0.43 s and her velocity down the slope at C is 5.0 ms−1.Calculate her velocity down the slope at B.   velocity = ............................ ms−1 **(3)****Q48(b)** The combined mass of the snowboarder and snowboard is 75 kg and the angle of the slope is 25°.**Q48(bi)** Calculate the component of the weight of the snowboarder and snowboard acting down the slope.   weight component = ................................. N **(2)****Q48(bii)** At D the snowboarder has reached a constant velocity. She moves a distance of 2.0 m at constant velocity between D and E. Calculate the work done against resistive forces as she moves from D to E.  work done = ................................... J **(1)****Q48(c)** State and explain what happens to the gravitational potential energy lost between D and E......................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................... **(3)** **(Total 9 marks)****Q49.**   A cyclist **pedals** downhill on a road, as shown in the diagram below, from rest at the top of the hill and reaches a horizontal section of the road at a speed of 16 m s–1. The total mass of the cyclist and the cycle is 68 kg.**Q49(ai)**  Calculate the total kinetic energy of the cyclist and the cycle on reaching the horizontal section of the road.    answer ............................ J **(2)****Q49(aii)** The height difference between the top of the hill and the horizontal section of road is 12 m.Calculate the loss of gravitational potential energy of the cyclist and the cycle.   answer ........................... J **(2)****Q49(aiii)** The work done by the cyclist when pedalling downhill is 2400 J. Account for the difference between the loss of gravitational potential energy and the gain of kinetic energy of the cyclist and the cycle......................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................... **(3)****Q49(b)**  The cyclist stops pedalling on reaching the horizontal section of the road and slows to a standstill 160 m further along this section of the road. Assume the deceleration is uniform. Calculate the time taken by the cyclist to travel this distance.  answer................................. s **(3)** **(Total 10 marks)** |

**Saturday: Momentum and Energy Checklist**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| # |  | I can… |  ☹ |  😐 |  ☺ |
| 120 |  | Calculate momentum using the momentum equation. |  |  |  |
| 121 |  | Rearrange the momentum equation to find the unknown. |  |  |  |
| 122 |  | Recall or deduce the units of momentum. |  |  |  |
| 123 |  | Explain what is meant by the conservation of momentum. |  |  |  |
| 124 |  | Describe when the conservation of momentum applies. |  |  |  |
| 125 |  | Calculate the total momentum before a collision. |  |  |  |
| 126 |  | Calculate the velocity after a collision. |  |  |  |
| 127 |  | Calculate the total momentum before an explosion. |  |  |  |
| 128 |  | Calculate the mass after an explosion. |  |  |  |
| 129 |  | Calculate the velocity after an explosion. |  |  |  |
| 130 |  | Explain what is meant by an elastic collision. |  |  |  |
| 131 |  | Explain what is meant by an inelastic collision. |  |  |  |
| 132 |  | Describe the relationship between force and momentum. |  |  |  |
| 133 |  | Calculate force from the force-momentum equation. |  |  |  |
| 134 |  | Rearrange the force-momentum equation to find the unknown. |  |  |  |
| 135 |  | Describe the effect on a force when a change is made. |  |  |  |
| 136 |  | Describe car safety features. |  |  |  |
| 137 |  | Explain how car safety features work. |  |  |  |
| 138 |  | Define the term impulse. |  |  |  |
| 139 |  | Explain what an impulse can cause. |  |  |  |
| 140 |  | Calculate an impulse using the impulse equation. |  |  |  |
| 141 |  | Recall or deduce the units of impulse. |  |  |  |
| 142 |  | Rearrange the impulse equation to find the change in momentum. |  |  |  |
| 143 |  | Rearrange the impulse equation to find the change in velocity. |  |  |  |
| 144 |  | Rearrange the impulse equation to find the final velocity. |  |  |  |
| 145 |  | Explain why ‘following through’ in a sport results in a higher speed. |  |  |  |
| 146 |  | Take measurements from a force-time graph. |  |  |  |
| 147 |  | Describe what the area under a force-time graph represents. |  |  |  |
| 148 |  | Calculate work done using the work done equation. |  |  |  |
| 149 |  | Rearrange the work done equation to find the unknown. |  |  |  |
| 150 |  | Calculate work done when the distance moved is at angle *θ* to the direction of the force. |  |  |  |
| 151 |  | Define the term power. |  |  |  |
| 152 |  | Calculate power using the power-energy equation. |  |  |  |
| 153 |  | Rearrange the power-energy equation to find the unknown. |  |  |  |
| 154 |  | Calculate power using the power-force equation. |  |  |  |
| 155 |  | Rearrange the power-force equation to find the unknown. |  |  |  |
| 156 |  | Describe what the area under a force-displacement graph represents. |  |  |  |
| 157 |  | Take measurements from a force-displacement graph. |  |  |  |
| 158 |  | Identify what work is being done against. |  |  |  |
| 159 |  | Identify energy transfers/transformations. |  |  |  |
| 160 |  | Explain what is meant by the conservation of energy. |  |  |  |
| 161 |  | Calculate gravitational potential energy using the GPE equation. |  |  |  |
| 162 |  | Rearrange the GPE equation to find the unknown. |  |  |  |
| 163 |  | Calculate kinetic energy using the kinetic energy equation. |  |  |  |
| 164 |  | Rearrange the KE equation to find the unknown. |  |  |  |
| 165 |  | Calculate the maximum height that could be reached using KE and GPE equations. |  |  |  |
| 166 |  | Explain why the height reached is not the maximum possible value. |  |  |  |
| 167 |  | Calculate the maximum speed that could be reached using KE and GPE equations. |  |  |  |
| 168 |  | Explain why the speed reached is not the maximum possible value. |  |  |  |
| 169 |  | Calculate the work done against resistive forces. |  |  |  |
| 170 |  | Explain what is meant by efficiency. |  |  |  |
| 171 |  | Calculate efficiency using the efficiency equation. |  |  |  |
| 172 |  | Rearrange the efficiency equation to find the unknown. |  |  |  |
| 173 |  | Convert efficiencies from percentages to decimals. |  |  |  |
| 174 |  | Convert efficiencies from decimals to percentages. |  |  |  |