To correct: **2018 Question 6 (c)**

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### 2002

**Total resistance**

Rparallel = 2 Ω

**Total voltage: 1.5 V**

**Total current flowing in the circuit**

= 0.75 A

**Current flowing through 3 Ω resistor**

= 0.5 A

### 2003

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| *2003??* | |
| An astronaut is on the surface of the moon, where the acceleration due to gravity is 1.6 m s–2.  The astronaut throws a stone straight up with an initial speed of 25 m s–1.  Calculate the highest point reached by the stone. | |
| *u* = 25 m s–1  *v* = 0  *a* = - 1.6 m s–2  *s* = ?  *t* = | *v*2 = *u*2 + 2*as*   0 = (25)2 + 2 (-1.6)(*s*)   s = 195.3 m. |
|  | |
| Calculate how high the astronaut can throw the same stone with the same initial speed of 25 m s–1 when on the surface of the earth, where the acceleration due to gravity is 9.8 m s–2. | |
| *u* = 25 m s–1  *v* = 0  *a* = - 9.8 m s–2  *s* = ?  *t* = | *v*2 = *u*2 + 2*as*   0 = (25)2 + 2 (-9.8)(*s*)   *s* = 31.9 m. |
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| A student throws a ball vertically upwards. The ball leaves the student’s hand at a velocity of 7 m s-1 when it is 130 cm above the ground.  Calculate the maximum height, above the ground, the ball will reach | |
| *u* = 7 m s–1  *v* = 0  *a* = - 9.8 m s–2  *s* = ?  *t* = | *v*2 = *u*2+ 2*as*   0 = (7)2 + 2(-9.8)(*s*)   *s* = 2.50 m   max. height = 2.5 + 1.30 = 3.8 m |
|  | |
| **Remember the importance of signs!** | |
| Calculate the time taken for the ball to hit the ground after its release in the previous question. | |
| *u* = 7 m s–1  *v* =  *a* = - 9.8 m s–2  *s* = - 1.3 m s-2  *t* = | s = *ut* + ½ *at*2   -1.30 = 7*t* – ½ (9.8)*t*2   4.9*t*2  - 7t-1.3 = 0   Solve this quadratic equation to get *t* = 1.59 s |

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| **Example 1**  **2003 Question 5 [Ordinary level]**  What is the momentum of an object with a mass of 5 kg travelling at 10 m s-1? | **Solution**  Momentum = mass × velocity  = 5 × 10 = 50 kg m s-1. |

**2003 Question 6 [Ordinary Level]**

1. An astronaut has a mass of 120 kg. What is the weight of the astronaut on the surface of the moon where acceleration due to gravity is 1.6 m s–2
2. The astronaut throws a stone straight up from the surface of the moon with an initial speed of 25 m s–1. Describe how the speed of the stone changes as it reaches its highest point.
3. Calculate the highest point reached by the stone.
4. Calculate how high the astronaut can throw the same stone with the same initial speed of 25 m s–1 when on the surface of the earth, where the acceleration due to gravity is 9.8 m s–2.
5. Why is the acceleration due to gravity on the moon less than the acceleration due to gravity on the earth?

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| **Part (i)**  m = 120 kg  *g* = 1.6 m s–2 | W = m*g* = (120)(1.6) = 192 N. |
| **Part (ii)** | It slows down as it rises until at the highest point its speed is 0. |
| **Part (iii)**  *u* = 25 m s–1  *v* =0  *g* = 1.6 m s–2 | *Note that at the highest point the velocity is 0.*  *v2 = u2 + 2as* ⇒ 0 = (25)2 + 2 (-1.6)*s*  ⇒ *s* = 195.3 m. |
| **Part (iv)**  *u* = 25 m s–1  *v* =0  *g* = 9.8 m s–2 | *v2 = u2 + 2as* ⇒ 0 = (25)2 + 2 (-9.8) s  ⇒ *s* = 31.9 m. |
| **Part (v)** | The earth has a greater mass than the moon. |

### 2004

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| **Example 3 [2004 OL]**  A person jumping over a block  Description automatically generatedThe diagram shows a child stepping out of a boat onto a pier.  The boat, which was initially at rest, has a mass of 50 kg.  The child [who was also initially at rest] has a mass of 40 kg and steps out with a velocity of 2 m s−1 towards the pier.  Calculate the velocity of the boat as it moves backwards immediately after the child steps out. | |
| **Solution**  Total momentum before = Total momentum after  m1u1 + m2u2  = m1v1 + m2v2  0 + 0 = (40)(2) + (50)(v2)  -80 = (50) v2  v2 = - 1.6 m s-1 | **Comment**  The child and boat were both at rest initially so total momentum beforehand is zero.  Notice that the final velocity is a negative number, indicating that the boat moves off in the opposite direction to the child. That’s the power of vectors my friend. |

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| **2004 Question 8 [Ordinary Level]**  A note of wavelength 1.4 m is produced from a stretched string. If the speed of sound in air is 340 m s−1 calculate the frequency of the note. | ***λ*** = 1.4 m  *c* = 340 m s-1  ***c = f λ*** 242.86 m s-1 |

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| **2004 Question 12 (b) [Ordinary Level]**  A concave mirror has a focal length of 20 cm. An object is placed 30 cm in front of the mirror.  How far from the mirror will the image be formed? | |
| *focal length f* = 20 cm  *object distance u* = 30 cm | Answer: *v* = 60 cm |

### 2005

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| **2005 Question 7 [Ordinary Level]**  A glass block has a critical angle of 41.8°. Calculate a value for the refractive index of the glass. | ⇒ *n* = 1.5 |

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| **2005 Question 5 [Ordinary level]**  A car accelerates from 10 m s−1 to 30 m s−1 in 5 seconds. What is its acceleration? | |
| *u* = 10 m s−1  *v* = 30 m s−1  *a* = ?  *s* =  *t* = 5 s | v = u + at ⇒ a = ( v – u ) ÷ t  ⇒ a = (30 – 10) ÷ 5  ⇒ a = 4 m s-2. |

### 2006

**2006 Question 6 [Ordinary Level]**

1. Define the term force and give the unit in which force is measured.
2. Explain the term acceleration due to gravity, *g*.
3. Use this data to show that the acceleration due to gravity on the surface of the moon is 1.6 m s–2.
4. The astronaut has a mass of 120 kg.

Calculate his weight on the surface of the moon.

1. Why is the astronaut’s weight greater on earth than on the moon?
2. Explain why the moon does not have an atmosphere.

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| **Part (i)** | A force is something which causes an acceleration.  The unit of force is the newton. |
| **Part (ii)** | It is the acceleration of an object which is in freefall due to the gravitational pull of the earth. |
| **Part (iii)**  *s* = 1.6 m  *t* = 1.4 s  *u* = 0. | *s = ut + ½ at2*  1.6 *=* 0 *+* ½ (*a*)(1.4)*2*  *a* = 1.6 m s-2. |
| **Part (iv)** | W = m*g* ⇒ W = (120)(1.6) = 192 N. |
| **Part (v)** | Because acceleration due to gravity is greater on the earth (or because the mass of the earth is greater than the mass of the moon). |
| **Part (vi)** | Because the gravitational force is less on the moon. |

**2006 Question 7 (b) [Ordinary Level]**

The total mass of the bricks in a storage heater is 80 kg and their specific heat capacity is 1500 J kg–1 K–1.

During a ten-hour period the temperature of the bricks rose from 15 oC to 300 oC.

1. Calculate the energy gained by the bricks;
2. Calculate the power of the heating coil.

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| **Part (i)**  *m* = 80 kg  Δθ = (300 – 15)  c = 1500 J kg−1 K–1 | E= *mcΔθ* = (80)(1500)(285) = 34 200000 J = 3.4 MJ |
| **Part (ii)** | = 950 W |

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| **2006 Question 8 [Ordinary Level]**  A ship detects the seabed by reflecting a pulse of high frequency sound from the seabed.  The speed of sound in water is 1500 m s–1.  Calculate the wavelength of the sound pulse when its frequency is 50 000 Hz. | *f* = 50000 Hz  *c* = 1500 m s−1  ***c = f λ*** *λ = 0.03 m* |

### 2007

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| **Example 2 [2007 OL]**  Two shopping trolleys each of mass 12 kg are on a smooth level floor.  Trolley A moving at 3.5 m s−1 strikes trolley B, which is at rest.  After the collision both trolleys move together in the same direction.  Calculate the common velocity of the trolleys after the collision. | |
| **Solution**  Total momentum before = Total momentum after  m1u1 + m2u2  = m1v1 + m2v2  (12)(3.5) + 0 = m1v1 + m2v2  42 = m3v3  42 = 24v3  v3= 42/24  v3= 1.75 m s-1 | **Comment**  The two trolleys are moving off together afterwards so we can treat them as one object which has a combined mass of 24 kg and is moving at a velocity v3. |

**2007 Question 6 [Ordinary Level]**

1. An empty lift has a weight of 7200 N and is powered by an electric motor.

The lift takes a person up 25 m in 40 seconds.

The person weighs 800 N.

Calculate the total weight raised by the lift’s motor.

1. Calculate the work done by the lift’s motor.
2. Calculate the power output of the motor.
3. Calculate the energy gained by the person in taking the lift.
4. If instead the person climbed the stairs to the same height in 2 minutes, calculate the power generated by the person in climbing the stairs.
5. Give two disadvantages of using a lift.

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| **Part (i)** | 7200 + 800 = 8000 N |
| **Part (ii)** | Work = Force × distance = 8000 × 25 = 200,000 J |
| **Part (iii)** | Power = work/time =200,000/40 = 5000 W |
| **Part (iv)** | Energy gained = potential energy = Force × distance = 800 × 25 = 20,000 J |
| **Part (v)** | Work = Force × distance = 800 × 25 = 20000 J  Power = work/time = (20000)/120 = 166.6 W |
| **Part (vi)** | Needs electrical energy which uses fossil fuels / no exercise so not good for health /cost involved |

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| **2007 Question 7 [Ordinary Level]**  A tin-whistle produces a note of 256 Hz. Calculate the wavelength of this note.  The speed of sound in air is 340 m s−1. | *f* = 256 Hz  *c* = 340 m s-1  ***c = f λ*** 1.33 m |

### 2008

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| **2008 Question 5 [Ordinary level]**  A solid block in the shape of a cube of length 120 cm rests on a table.  The weight of the block is 25 N.  Calculate the pressure it exerts on the table. | Force = weight =25 N area = 1.2 m2    P = 17.4 pa |

**2008 Question 6 [Ordinary Level]**

1. Calculate the acceleration due to gravity on the moon.

The radius of the moon is 1.7 × 106 m and the mass of the moon is 7 × 1022 kg.

1. A lunar buggy designed to travel on the surface of the moon had a mass of 2000 kg when built on the earth.

What is the weight of the buggy on earth?

1. What is the mass of the buggy on the moon?
2. What is the weight of the buggy on the moon?
3. A powerful rocket is required to leave the surface of the earth.

A less powerful rocket is required to leave the surface of the moon. Explain why.

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| **Part (i)**  radius = 1.7 × 106 m  radius of the moon is 1.7 × 106 m | *g* = 1.6 m s-2 |
| **Part (ii)** | *W* = *mg* = 2000 × 9.8 = 19600 N |
| **Part (iii)** | 2000 kg |
| **Part (iv)** | *W* = *mg* = 2000 × 1.6 = 3200 N |
| **Part (v)** | The force of gravity is less on moon so less force is needed to overcome the gravitational attraction to the moon |

**2008 Question 7 (c) [Ordinary Level]**

A saucepan containing 500 g of water at a temperature of 20 °C is left on a 2 kW ring of an electric cooker until it reaches a temperature of 100 °C.

All the electrical energy supplied is used to heat the water.

1. Calculate the rise in temperature of the water.
2. Calculate the energy required to heat the water to 100 °C.
3. Calculate the amount of energy the ring supplies every second.
4. Calculate the time it will take to heat the water to 100 °C.

(specific heat capacity of water = 4200 J kg−1 K−1)

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| **Part (i)** | 100 – 20 = 80 °C |
| **Part (ii)**  *m* = 0.5 kg  *Δθ* = 80 °C | Q = *m*c*Δθ* = (0.5)(4200)(80) = 168 000 J |
| **Part (iii)** | 2 kW = 2,000 W = 2,000 J per second. |
| **Part (iv)** | = 84 seconds |

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| **Worked example**  **2008 Question 12 (a) [Ordinary Level]**  A speedboat starts from rest and reaches a velocity of 20 m s−1 in 10 seconds.  It continues at this velocity for a further 5 seconds.  The speedboat then comes to a stop in the next 4 seconds.   1. Draw a velocity-time graph to show the variation of velocity of the boat during its journey. 2. Use your graph to estimate the velocity of the speedboat after 6 seconds. 3. Calculate the acceleration of the boat during the first 10 seconds. 4. What was the distance travelled by the boat when it was moving at a constant velocity? | |
| **Part (i)**  See graph |  |
| **Part (ii)** | 1. See dotted line on the graph:   *v* = 12 m s-1. |
| **Part (iii)**  *u* = 0  *v* = 20 m s-1  *a* =  *s* =  *t* = 10 s | *v* = *u* + *at*  20 = 0+ *a*(10)  a = 2 m s-2 |
| **Part (iv)** | Distance travelled by the boat when it was moving at a constant velocity = area under this section of the graph.  Height = 20, base = 5  Area = 20×5 = 100 m |

### 2009

**2009 Question 6 [Ordinary Level]**

**See solution to this one in Booklet 2 and cross out energy questin and put this question at the end of this booklet**

1. The diagram shows the forces acting on a train which was travelling horizontally.

A train of mass 30000 kg started from a station and accelerated at 0.5 m s−2 to reach its top speed of 50 m s−1 and maintained this speed for 90 minutes.

As the train approached the next station the driver applied the brakes uniformly to bring the train to a stop in a distance of 500 m.

Calculate how long it took the train to reach its top speed.

1. Calculate how far it travelled at its top speed.
2. Calculate the acceleration experienced by the train when the brakes were applied.
3. What was the force acting on the train when the brakes were applied?
4. Name the force A and the force B acting on the train, as shown in the diagram.
5. Describe the motion of the train when the force A is equal to the force T.
6. Sketch a velocity-time graph of the train’s journey.

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| **Part (i)**  *u* = 0  *v* = 50 m s–1  *a* = 0.5 m s–2  *s* =  *t* = ? | *v* = *u* + *at*  50 = 0 + 0.5*t*  *t* = 50/0.5 = 100 s |
| **Part (ii)**  *u* = 0  *v* = 50 m s–1  *a* = 0.5 m s–2  *s* =  *t* = | *s* = *ut* + ½ *at*2 (but *a* = 0) so we just use *s* = *ut*  90 minutes = (90×60) = 540 seconds  *s* = *ut* = 50 × (540) = 270000 m |
| **Part (iii)**  *u* = 50 m s–1  *v* = 0  *a* = ?  *s* = 500 m  *t* = | *v*2 = *u*2 + 2*as*  0 = 502 + 2*a*(500)  *a* = −2500/1000 = − 2.5 m s-1 |
| **Part (iv)** | *F* = m*a*  *F* = 30000 × (−)(2.5) = - 75000 N = 75 kN |
| **Part (v)** | A = friction/retardation / resistance to motion  B = weight / force of gravity |
| **Part (vi)** | The train will move at constant speed |
| **Part (vii)** |  |

### 2010

**2010 Question 6 [Ordinary Level]**

1. An ice skater of mass 50 kg was moving with a speed of 6 m s−1 then she collides with another skater of mass 70 kg who was standing still. The two skaters then moved off together.

Calculate the momentum of each skater before the collision?

1. What is the momentum of the combined skaters after the collision?
2. Calculate the speed of the two skaters after the collision.
3. Calculate the kinetic energy of each skater before the collision.
4. Calculate the kinetic energy of the pair of skaters after the collision.
5. Comment on the total kinetic energy values before and after the collision.

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| **Part (i)** | First skater: mass = 50 kg, velocity = 6 m s−1 Momentum = 50 × 6 = 300 kg m s−1  Second skater: mass = 70 kg, velocity = 0 m s−1  Momentum = 70 × 0 = 0 kg m s−1 |
| **Part (ii)** | Total momentum beforehand = 300 kg m s−1 therefore total momentum of the combined skaters afterward must also be 300 kg m s−1. |
| **Part (iii)** | Total momentum after = 300 kg m s−1  Momentum after = (m1 + m2) *v*3  300 = (50 + 70)( *v*3)  *v*3= 2.5 m s−1 |
| **Part (iv)** | *E*k *=* ½*mv*2  First skater: mass *= 50 kg and velocity = 6 m s-1. E*k *=* ½ 50 × 62 = 900 J  Second skater: mass *= 70 kg and velocity = 0 m s-1. E*k = ½ 70 × 0 = 0 J |
| **Part (v)** | *E*k *=* ½*mv*2  Combined mass *= 120 kg and velocity = 2.5 m s-1.*  *E*k *=* ½ 120 × (2.5)2 = 375 J |
| **Part (vi)** | Kinetic energy not conserved in collision because some of the energy was given off as heat and sound. |

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| **2010 Question 7 [Ordinary Level]**  If the frequency of a string is 250 Hz calculate the wavelength of the sound wave produced  (speed of sound = 340 m s-1). | *f* = 250 Hz  *c* = 340 m s-1  ***c = f λ*** 1.36 m |

**2010 Question 9 (b) [Ordinary Level]**

The diagram shows a number of resistors connected to a 12 V battery and a bulb of resistance is 4 Ω.

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1. Calculate the combined resistance of the 15 Ω and 30 Ω resistors in parallel.
2. Calculate the total resistance of the circuit
3. Calculate the current flowing in the circuit

**Solution**

**Total resistance**

Rparallel = 10 Ω

We now have to add the 10 Ω resistor and the resistance of the bulb (4 Ω). These are all in series so we can just add them directly to give a total resistance of 24 Ω.

**Total voltage: 12 V**

**Total current flowing in the circuit**

= 0.5A.

*Let’s assume that the question went on to ask us to calculate the potential difference across each resistor and the current flowing through each resistor.*

Begin by looking at the isolated resistor(s):

10 Ω resistor: I = 0.5 A R = 10 Ω V = IR = (0.5)(10) = 5 volts

Lightbulb (4 Ω): I = 0.5 A R = 4 Ω V = IR = (0.5)(4) = 2 volts

**Finally let’s look at resistors in parallel.**

Voltage across resistors in parallel = 12 – (5 + 2) = 5 volts therefore the potential difference across both the 15 Ω and the 30 Ω resistors is 5 V.

To find *I* we use = 0.33 A = 0.17 A

### 2011

**2011 Question 6 [Ordinary Level]**

A car of mass 1400 kg was travelling with a constant speed of 15 m s-1 when it struck a tree and came to a complete stop in 0.4 s.

1. State Newton’s first law of motion.
2. Draw a diagram of the forces acting on the car before it hit the tree.
3. Calculate the acceleration of the car during the collision.
4. Calculate the net force acting on the car during the collision.
5. A back seat passenger could injure other occupants during a collision.

Explain, with reference to Newton’s laws of motion, how this could occur.

1. How is this risk of injury minimised?

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| **Part (i)** | A body will remain at rest or moving at a constant velocity unless acted on by an (external) force, |
| **Part (ii)** |  |
| **Part (iii)** | *v = u + at* a = 37.5 m s-2 |
| **Part (iv)** | *F*net= ma *F*net = 1400 × 37.5 = 52500 N |
| **Part (v)** | Even though the car comes to a stop the back-seat passenger will continue to move forward (from Newton’s first law of motion) and so could collide with someone in the front. |
| **Part (vi)** | By wearing a seat belt. |

### 2012

**2012 Question 6 [Ordinary Level]**

1. ****A spacecraft has a mass 800 kg and is on the surface of the moon where the acceleration due to gravity is 1.6 m s−2.

Compare the weight of the spacecraft on the surface of the moon with its weight on earth, where the acceleration due to gravity is 9.8 m s–2.

1. The module of the spacecraft has a mass of 600 kg and is launched vertically from the surface of the moon with its engine exerting an upward force of 2000 N.

Draw a diagram showing the forces acting on the module at lift-off.

1. What is the resultant force on the module?
2. Calculate the acceleration of the module during lift-off.
3. Calculate the velocity of the module, 20 seconds after lift-off.
4. Would the engine of the module be able to lift it off the earth’s surface? Justify your answer in terms of the forces acting on the module.
5. Why is the acceleration due to gravity on the moon less than the acceleration due to gravity on earth?
6. Suggest a reason why the module of the spacecraft when launched from the moon does not need a streamlined shape like those that are launched from earth.

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| **Part (i)** | Weight on moon = *mg*m= (800)(1.6) = 1280 N  Weight on earth = *mg*e = (800)(9.8) = 7840 N  So the spacecraft is (7840 ÷ 1280) = 6.1 times heavier on the earth than on the moon. |
| **Part (ii)** | **A diagram of a space ship  Description automatically generated**Weight acting down, thrust acting up. Note the arrow for Thrust has got to be longer than the arrow for weight. |
| **Part (iii)** | *Fnet = (*Fbig – Fsmall*) = (Thrust* - *weight*)  *Thrust = 2000 N*  *Weight on the moon = mg = (600)(1.6) = 320 N*  *Fnet =* [2000 - 320] = 1040 N |
| **Part (iv)** | *Fnet* = 1040 N *m* = 600 kg  *Fnet* =*ma*  ⇒ 1040 = (600)(*a*)  ⇒ *a* = 1.73 m s-2 |
| **Part (v)**  u = 0,  *a* = 1.73 m s-2,  *t* = 20 s | *v = u + at*  *v* = 0 + (1.73)(20) = 34.6 m s-1 |
| **Part (vi)** | No. The force of gravity on the earth is 5880 N (600 × 9.8) and the upward thrust of the spacecraft is only 2000 N. |
| **Part (vii)** | Because the mass of the moon is less than the mass of the earth |
| **Part (viii)** | There is no atmosphere on the moon so no air resistance / drag / friction |

Question 9

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| **Part (i)**  *m* = 20 ×10-3 kg  *l* = 3.34 ×105 J kg−1 | *Q* = *ml* = (20 ×10-3)(3.34 ×105) = 6.68 ×103 J |
| **Part (ii)**  *m* = 20 ×10-3 kg  c = 4.18 ×103 J kg−1 K−1  Δθ = (5 – 0) = 5 °C | *Q* = mcΔθ = (20×10-3)(4.18 ×103)(5) = ) 418 J |

### 2013

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| **2013 Question 5 [Ordinary level]**  The spanner shown in the diagram is used to turn a nut.  Calculate the moment of the force applied by the spanner to the nut. | 50 × 0.1 = 5 N m |

**2013 Question 6 [Ordinary Level]**

A truck of mass 5000 kg is moving with a velocity 10 m s−1 when it collides with a stationary car with a mass of 1000 kg. The truck and the car then move off together.



1. Calculate the momentum of the truck and the car before the collision.
2. What is the momentum of the combined vehicles after the collision?
3. Calculate the velocity of the combined vehicles after the collision.
4. What is the momentum of the truck after the collision?
5. If the collision between the truck and the car takes 0.3 seconds, calculate the force exerted by the truck on the car.

**Solution**

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| **Part (i)** | Only the truck is moving so the only velocity is associated with the truck:  5000 × 10 = 50000 kg ms-1 |
| **Part (ii)** | Total momentum is the same before and after the interaction, so momentum after collision also is 50000 kg m s-1 |
| **Part (iii)** | Total momentum afterwards = 50000 kg ms-1  Total mass afterwards = 5000 + 1000 = 6000 kg    50000 = 6000 × *v*  *v* = 50000 ÷ 6000 = 8.3 m s-1 |
| **Part (iv)** | (8.3 × 5000) = 41500 kg m s−1 |
| **Part (v)** | Impulse = Ft = (mv – mu)  Momentum before (mu) = 50000 kg ms-1  Momentum after (mv) = 41500 kg ms-1  Force = [(mu – mv)÷time] = [(50000 – 41500) ÷ 0.3] = 27800 N |

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| **2013 Question 6 [Ordinary Level]**  When a truck hits the back of the car the car driver’s airbag inflates. The airbag deflates when it is hit by the driver’s head. Explain why the airbag reduces the risk of injury to the driver. | Using an airbag increases the time it takes for the drivers head to come to a stop (compared to having it hit off the windscreen).  From the equation Force = [(mu – mv)÷time] we can see that if time increases then the force (exerted on the driver’s head) decreases. |

**2013 Question 9 (b) [Ordinary Level]**

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| **Part (i)**  *m* = 1.3 kg  Δθ = (80 – 10)  c = 4200 J kg−1 K–1 | E= *mcΔθ* = (1.3)(4200)(70) = 380000 = 3.8 ×105 J |
| **Part (ii)** | = 2123.3 W |

2014

****2014 Question 6 [Ordinary Level]**

1. Calculate, to one decimal place, the acceleration due to gravity on Mars.

The radius of Mars is 3.4 × 106 m and the mass of Mars is 6.4 × 1023 kg.

1. In August 2012 the *Curiosity* rover landed on Mars.

The wheels of the rover are not as strong as the wheels that would be needed if the rover was to be used on Earth. Give a reason for this.

1. The *Curiosity* rover was built on Earth to travel on the surface of Mars.   
   The rover has a mass of 899 kg. Calculate the weight of *Curiosity* on Earth.
2. What is the mass of the buggy on the moon?
3. What is the weight of the buggy on the moon?

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| **Part (i)**  radius of Mars is 3.4 × 106 m  mass of Mars is 6.4 × 1023 kg. | *g* = 3.7 m s-2 |
| **Part (ii)** | the rover weighs less on Mars // force of gravity is less on Mars // the mass of Mars is smaller than mass of Earth |
| **Part (iii)** | *W = mg* = (899)(9.8) = 8.8 × 103 N |
| **Part (iv)** | 899 (kg) // the same as on Earth |
| **Part (v)** | *W = mg* = (899)(3.7) = 3.3 × 103 N |

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| **2014 Question 12 (a)** [Ordinary Level]  A bus leaves a bus stop and accelerates from rest at 0.5 m s−2 to reach a speed of 15 m s−1.  It then maintains this speed for 100 seconds. When it approaches the next stop, the driver applies the brakes uniformly to bring the bus to a stop in 20 seconds.   1. Calculate the time it took the bus to reach its top speed. 2. Calculate the distance it travelled while at its top speed. 3. Calculate the acceleration required to bring the bus to a stop. 4. Sketch a velocity-time graph of the bus journey. | |
| **Part (i)**  *u* = 0  *v* = 15 m s−1  *a* = 0.5 m s−2  *s* =  *t* = ? | *v = u + at*  *15 = 0 + 0.5t*  *t* = (15 ) / 0.5 = 30 s |
| **Part (ii)**  *u* = 15 m s−1  *v* = 15 m s−1  *a* = 0  *s* =  *t* = 100 s | *s* = *ut + ½ at2*  *s* = (15)(100) + ½ (0)(100)2 = 1500 m |
| **Part (iii)**  *u* = 15 m s−1  *v* = 0  *a* = ?  *s* =  *t* = 20 s | *v = u + at*  *0 = 15 + a(20)*  *a=* (15 ) / 20 = – 0.75 m s –2 |
| **Part (iv)**  see graph | **Chart, line chart  Description automatically generated** |

### 2014

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| **2014 Question 12 (c) [Ordinary Level]**  20 waves pass a fixed point every second.  What is the frequency of the wave?  Calculate the velocity of the wave if the wavelength is 1.5 m. | *f* = 3 Hz  ***λ*** = 1.5 m  ***c = f λ***  ***c*** = (3)(1.5)**=** 4.5 m s−1 |

### 2015

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| **2015 Question 5 [Ordinary level]**  A glass block has a critical angle of 42°.  Calculate the refractive index of the glass used in the block. | = n = 1.49 |

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| **2015 Question 5 [Ordinary level]**  A small stone is thrown straight up from the ground with an initial speed of 20 m s−1. Calculate the height it has reached after two seconds. | |
| *u* = 20 m s–1  *v* =  *a* = - 9.8 m s–2  *s* = ?  *t* = 2 s | *s* = *ut* + ½ *at*2 *s* = *(20)(2)* - ½ *(9.8)(2)*2 *s* = 20.4 m |
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**2015 Question 6 [Ordinary Level]**

1. State the principle of conservation of energy
2. Explain how the principle of conservation of energy applies to a roller-coaster.

Chart, line chart

Description automatically generated

A roller-coaster car of mass 850 kg is released from rest at point A of the track, as shown in the diagram.

1. Calculate the difference in height between point A and point B.
2. Calculate the change in the potential energy of the car between A and B.
3. Write down the kinetic energy of the car at point B, assuming there is no friction and no air resistance.
4. Calculate its velocity at point B.
5. The brakes are applied at point B and the car comes to a stop at point C.

Calculate the deceleration of the car between B and C.

1. Calculate the average force required to bring the car to a stop.

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| **Part (i)** | The principle of conservation of energystates that energy cannot be created or destroyed but can only be converted from one form to another. |
| **Part (ii)** | Potential energy at top of roller-coaster is converted into kinetic energy as speed increases / height decreases |
| **Part (iii)** | 75 m |
| **Part (iv)** | Change in potential energy = potential energy at A – potential energy at B  = mgh1  – mgh2  = (850)(9.8)(100) – (850)(9.8)(25)   = 624750 J |
| **Part (v)** | Due to conservation of energy, *the* *potential energy lost* between A and B must equal *the kinetic energy gained.* The car lost 624750 J of potential energy so gained the same amount of kinetic energy, and given that it had no kinetic energy to begin with, its potential energy at B must be 624750 J. |
| **Part (vi)** | ½ m*v*2 = 624750 J ½ (850)*v*2 = 624750 J  *v*2 = 1470 *v* = 38.3 m s-1 |
| **Part (vii)**  *u* = 38.3  *v* = 0  *s* = 95 m | *v*2 = *u*2 +2*as* 0 = (38.3)2 + 2a(95)  (38.3)2 = - 190*a a* = -7.7 m s-2 |
| **Part (viii)**  *m =* 80 kg  *a* = 7.7 m s-1 | *F = ma*F = (80)(7.7) F = 6576 N |

### 2016

**2016 Question 8**

**Total resistance**

**Rparallel = 2 Ω**

**Total voltage: 12 V**

**Total current flowing in the circuit**

**= 6 A. This will also flow through the ammeter.**

**Current flowing through each 4 Ω resistor**

**= 3 A**

**Or you could have simply assumed that the total current of 6 A gets split evenly between both resistors.**

**2016 Question 9**

*Q = mcΔθ*  = 0.75 × 4200 × 20 = 63000 J

1. *Q = ml* = 0.75 × (3.3 × 105) = 247500 J
2. *Q = mcΔθ* = 0.75 × 2200 × 15 = 24750 J
3. time = 30 s
4. The water expands as it cools below 4 0C (and the glass contracts).

### 2017

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| **2017 Question 5 [Ordinary level]**  Text  Description automatically generated with medium confidenceA door handle is used to open a door. Calculate the moment of the force applied in the diagram. | Moment of a force = Force×distance  = 40 × 0.12  = 4.8 N m |

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| **Worked example**  **2017 Question 12 (a) [Ordinary Level]**  A car started from rest and accelerated at 0.4 m s−2 to reach a top speed of 28 m s−1.  It maintained this speed for 200 seconds.  The driver then applied the brakes uniformly to bring it to a stop in 30 s.   1. **Calculate how long it took the car to reach its top speed.** 2. **Sketch the velocity-time graph for the journey.** | |
| **Part (i)**  *u* = 0  *v* = 28 m s-1  *a* = 0.4 m s-2  *s* =  *t* = 10 s | *v* = *u* + *at*  28 = 0 + 0.4*t*  *t=* |
| **Part (ii)**  See diagram | **A red line with blue lines  Description automatically generated** |

### Diagram Description automatically generated2018

2018 Question 5 [Ordinary level]

Calculate the refractive index of the glass block shown in the diagram.

= 1.52

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| **2018 Question 12 (a) [Ordinary Level]**  A train left a station from rest and accelerated at 0.4 m s−2 to reach its top speed of 55 m s−1.  Calculate how long it took the train to reach its top speed. | |
| *u* = 0  *v* = 55 m s−1  *a* = 0.4 m s−2  *s* =  *t* = ? | *u* = 0  *v* = 55 m s−1  *a* = 0.4 m s−2  *s* =  *t* = ? |

### 2020

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| **2020 Question 6 [Ordinary Level]**  Calculate the resultant (net) force on the 9 kg  A picture containing diagram  Description automatically generatedobject in the diagram above. In what direction does it act? | There is a force of 6 N to the left and a total of 8 N (5 N + 3 N) to the right, so the net force is 8 N – 6N = 2 N towards the right |
| Calculate the acceleration of the 9 kg object. | Fnet = 2 N  m = 9 kg  *a* = ?  *Fnet*= m*a* = 0.22 m s-2 |

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| **2020 Question 6 [Ordinary Level]** This question is in a few pages before this one also   1. A block weighs 400 N. A crane lifts the block so that it moves upwards with constant velocity.  Use Newton’s first law of motion to find the force that the crane puts on the block. 2. Use Newton’s third law to explain how a rocket takes off. | |
| If it’s going at constant velocity then the net force acting on it must be zero so if the weight of the block is 400 N then the force upwards must also be 400 N. |
| when the rocket exerts a force downwards on the gas, the gas exerts an equal and opposite force upwards on the rock, causing the rocket to accelerate upwards. |

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| **2020 Question 6 [Ordinary Level]**  A car of mass 700 kg is at rest.  It accelerates at a constant rate for 6 seconds until it is travelling at a velocity of 18 m s–1.   1. Calculate the acceleration of the car. 2. Calculate the net force on the car as it accelerates.   The engine of the car provides a driving force of 3000 N.   1. Calculate the friction acting on the car. | |
| **Part (i)** | *u* = 0  *v* = 18 m s–1  *a* = ?  *s* =  *t* = 6 m  *v = u + at*  = 3 m s-2 |
| **Part (ii)** | *Fnet = ma* = (700)(3) = 2100 N |
| **Part (iii)** | There are two forces acting on the car in this question. We know the driving force is 3000 N and we know that the net force is 2100 N. We can use this to calculate the friction force as follows:  Fengine – Ffriction = 2100  Fengine – 2100 = Ffriction  3000 – 2100 = Ffriction  900 = Ffriction |

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| **2020 Question 12 (a) [Ordinary Level]**  A bus travels 30 km in 28 minutes at a constant speed.   1. Convert 30 km into metres. 2. Convert 28 minutes into seconds.   Use your answers to (i) and (ii) to calculate the speed of the bus in m s–1. | **Solution**   1. **Convert 30 km into metres.**  30000 m 2. **Convert 28 minutes into seconds.**  28 × 60 = 1680 s 3. **Calculate the speed of the bus in m s–1**.   = 17.86 m s-1 |

### 2021

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| **2021 Question 5 [Ordinary level]**  A motorcar starts from rest and has an acceleration of 6 m s–2.  Calculate the distance it travels in 12 s. | |
| *u* = 0  *v* = 30 m s−1  *a* = 6 m s−2  *s* =  *t* = 12 s | s = 432 m |

*A picture containing text, outdoor, traveling

Description automatically generatedWe tend to associate high momentum with objects moving fast, but it could just as easily be a very big slow-moving object – like the Bagger 293.*

**2021 Question 7 [Ordinary Level]**

The Bagger 293 excavator is the world’s largest land vehicle, with a mass of 14200 tonnes. (1 tonne = 1000 kg)

Bagger 293 has a maximum speed of 0.17 m s−1.

1. Calculate the momentum of Bagger 293 when it is moving at its maximum speed.
2. Bagger 293 is moving when it picks up a stationary load of 2700 tonnes.   
   Would this cause its speed to increase or to decrease?   
   Explain your answer.

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| **Part (i)** | Mass of excavator = 14200 tonnes = 14000 × 103 kg. velocity = 0.17 m s−1.  Momentum *=mv* = (14200 × 103)(0.17) = 2.4 × 106 kg m s-1 |
| **Part (ii)** | Momentum = mass × velocity and this number will be the same before and after the excavator picks up a load assuming no external forces act.  Once it picks up a load its overall mass will increase so if its overall momentum remains constant then this must mean that velocity decreases.  This is assuming no external forces come into play – is this a realistic assumption? |

**2021 Question 9 [Ordinary Level]**

*r* = 0.2 mm = 0.2 × 10-3 m *L* = 4.8 m

*ρ* = 1.1 × 10−6 Ω m.

= 1.2566 × 10-7 m2  
  
 = 42 Ω

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| **2021 Question 10 [Ordinary Level]**  An object of height 2 cm is placed 17 cm in front of **a concave mirror**.  An image with a height of 3 cm is formed.   1. Calculate the magnification. 2. Calculate the image distance. | |
| ***Image height = 3 cm***  ***Object height = 2 cm***  **M = ?** |  |
| ***Object distance u = 17 cm***  **M = 1.5**  ***v = ?*** | (*M*)(*u*) = *v* (1.5)(17) = *v* *v* = 25.5 cm |

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| **2021 Question 11 [Ordinary Level]**  The solar constant has a value of 1.36 kW m−2. On a particular day, sunlight falls on a garden  area of 54.0 square metresfor exactly 12 hours.  Calculate how much energy will fall on the garden in the 12 hours. | *1360 joules of solar energy fall on every square metre every second.*  *So total energy falling on 54.0 m2 over a period of 12 hours is*  = 1360 × 54 × 60 × 60 × 12  = 3.17 × 109 J |

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| **2021 Question 14 (d) [Ordinary Level]**  Waves on a stretched string travel at a speed of 380 m s−1.  When a stationary wave is set up on a string, the distance between two adjacent nodes is 40 cm.   1. Calculate the wavelength of the wave. 2. Calculate the frequency of the wave. | Rectangle  Description automatically generated with medium confidence | Distance between nodes =  = 0.4 m  λ = 0.8 m  c = 380 m s−1  ***c = f λ*** |

### 2022

**2022 Question 8**

1. 330000 × 0.2 = 66000 J
2. Steam has more energy – while both may be at the same temperature (100 0C) the steam contains more energy as it also contains the extra heat required to change it from a liquid to a gas – in this case an extra 660000 J of energy.

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| **2022 Question 10 [Ordinary Level]**  The frequency of a sound wave is 2800 Hz and it has a wavelength of 0.12 m.  Calculate the speed of the wave. | *f* = 2800 Hz  ***λ*** = 0.12 m  ***c = f λ c*** = (2800)(0.12)**=** 336 m s−1 |

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| **2022 Question 10 [Ordinary Level]**  A close-up of a glove  Description automatically generated with medium confidenceThe ear canal can be thought of as a pipe open at one end.  Draw a labelled diagram to show the first position of resonance for a sound wave in a pipe open at one end. |  |

**2022 Question 11**

**Part (i)**

R ∝ *l* so if the length doubles then the resistance will also double.

New resistance = (2)(1.2) = 2.4 Ω

**Part (ii)**

= 5 Amps

R = 3 Ω I = 5 A V = ?

V = RI = (3)(5) = 15 V

= = 1.2 Ω

**2022 Question 14 (a)** **[Ordinary Level]**

A boy picks up a stone of mass 5 g and throws it vertically upwards with an initialvelocity of 15 m s–1.   
As the stone travels upwards, it loses kinetic energy.

1. What is the main type of energy that the stone’s kinetic energy is being converted into as it travels upwards?
2. Calculate the kinetic energy of the stone when it is thrown.
3. Calculate the maximum height reached by the stone.

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| **Part (i)** | Potential energy |
| **Part (ii)**  m = 5 g = 0.005 kg  *v* = 15 m s–1 | E = ½m*v*2 E = ½(0.005)(152) = 0.5625 J |
| **Part (iii)**  E = 0.5625 J  m = 5 g = 0.005 kg  g = 9.8 N/kg | E = mgh  e    h = 11.5 m |

**2022 Question 14 (c)** **[Ordinary Level]**

The diagram shows a metre stick which is suspended from its mid‐point (50 cm) with three masses hanging from it. The metre stick is in equilibrium.

Chart, box and whisker chart

Description automatically generated

1. A moment is a turning effect caused by a force.

The 2 N force and the 4 N force result in clockwise moments about the midpoint of the metre stick. Calculate the total clockwise moment about the midpoint of the metre stick.

1. The 7 N force results in an anticlockwise moment about the midpoint of the metre stick.   
   Calculate the total anticlockwise moment about the midpoint of the metre stick.
2. State the law of equilibrium verified by the calculations in (*i*) and (*ii*).
3. The upward force on the metre stick is 15 N. Calculate the weight of the metre stick.
4. Your calculations assume that the centre of gravity of the metre stick acts at the mid‐point of the metre stick. What might cause this assumption to be invalid?

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| **Part (i)** | (2 × 0.1) + (4 × 0.3) = 1.4 N m |
| **Part (ii)** | 7 × 0.2 = 1.4 N m |
| **Part (iii)** | clockwise moments = anti-clockwise moments |
| **Part (iv)** | 15 – (7 + 2 + 4) = 2 N |
| **Part (v)** | **e.g. chipped metre stick etc.** |