Q1.
When two objects interact, they exert forces on each other.

(a) Which statement about the forces is correct?

Tick (✓) one box.

| The forces are equal in size and act in the same direction. |
| The forces are unequal in size and act in the same direction. |
| The forces are equal in size and act in opposite directions. |
| The forces are unequal in size and act in opposite directions. |

(b) A fisherman pulls a boat towards land.

The forces acting on the boat are shown in Diagram 1.

The fisherman exerts a force of 300 N on the boat.
The sea exerts a resistive force of 250 N on the boat.

Diagram 1

(i) Describe the motion of the boat.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

(ii) When the boat reaches land, the resistive force increases to 300 N.
The fisherman continues to exert a force of 300 N.

Describe the motion of the boat.

Tick (✓) one box.

Accelerating to the right

Constant velocity to the right
(1) Explain your answer to part (b)(ii).

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

(2) Another fisherman comes to help pull the boat. Each fisherman pulls with a force of 300 N, as shown in Diagram 2.

Diagram 2 is drawn to scale.

Add to Diagram 2 to show the single force that has the same effect as the two 300 N forces.

Determine the value of this resultant force.

Resultant force = __________________ N

(Total 10 marks)

Q2. Quantities in physics are either scalars or vectors.

(a) Use the correct answers from the box to complete the sentence.

<table>
<thead>
<tr>
<th>acceleration</th>
<th>direction</th>
<th>distance</th>
<th>speed</th>
<th>time</th>
</tr>
</thead>
</table>

Velocity is __________________________ in a given ________________ .

(2)

(b) Complete the table to show which quantities are scalars and which quantities are vectors.

Put one tick (✓) in each row.

The first row has been completed for you.
The diagram shows two supermarket trolleys moving in the same direction.  

Trolley A is full of shopping, has a total mass of 8 kg and is moving at a velocity of 2 m/s with a kinetic energy of 16 J.

Trolley B is empty, has a mass of 4 kg and is moving at a velocity of 0.5 m/s with a kinetic energy of 0.5 J.

(i) Calculate the momentum of both trolley A and trolley B.  

Give the unit.  

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Scalar</th>
<th>Vector</th>
</tr>
</thead>
<tbody>
<tr>
<td>Momentum</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Acceleration</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Force</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Momentum of trolley A = ______________

Momentum of trolley B = ______________

Unit __________

(ii) The trolleys in the diagram collide and join together. They move off together.  

Calculate the velocity with which they move off together.
Velocity = _________________ m / s

(iii) In a different situation, the trolleys in the diagram move at the same speeds as before but now move towards each other.

Calculate the total momentum and the total kinetic energy of the two trolleys before they collide.

______________________________________________________________________________
______________________________________________________________________________

Total momentum = _________________

______________________________________________________________________________

______________________________________________________________________________

Total kinetic energy = _________________ J

(Total 14 marks)

Q3.

The diagram shows a boat pulling a water skier.

(a) The arrow represents the force on the water produced by the engine propeller. This force causes the boat to move.

Explain why.

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

(2)

(b) The boat accelerates at a constant rate in a straight line. This causes the velocity of the water skier to increase from 4.0 m/s to 16.0 m/s in 8.0 seconds.

(i) Calculate the acceleration of the water skier and give the unit.

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

Acceleration = _________________________

(3)
(ii) The water skier has a mass of 68 kg. Calculate the resultant force acting on the water skier while accelerating.

Resultant force = ____________ N

(2)

(iii) Draw a ring around the correct answer to complete the sentence.

The force from the boat pulling the water skier forwards

less than the same as greater than

will be the answer to part (b)(ii).

Give the reason for your answer.

(2)

(Total 9 marks)

Q4.

A student suspended a spring from a laboratory stand and then hung a weight from the spring.

Figure 1 shows the spring before and after the weight is added.

(a) Which distance gives the extension of the spring?

Tick one box.
(b) The student used the spring, a set of weights and a ruler to investigate how the extension of the spring depended on the weight hanging from the spring.

Figure 2 shows that the ruler is in a tilted position and not upright as it should be.

How would leaving the ruler tilted affect the weight and extension data to be recorded by the student?

Use answers from the box to complete each sentence.

Each answer may be used once, more than once or not at all.

<table>
<thead>
<tr>
<th>greater than</th>
<th>the same as</th>
<th>smaller than</th>
</tr>
</thead>
</table>

The weight recorded by the student would be _________________ the actual weight.

The extension recorded by the student would be _________________ the actual extension of the spring.

(2)

(c) The student moves the ruler so that it is upright and not tilted.

The student then completed the investigation and plotted the data taken in a graph.

The student's graph is shown in Figure 3.
Use Figure 3 to determine the additional force needed to increase the extension of the spring from 5cm to 15cm.

Additional force = ______________________ N

(d) What can you conclude from Figure 3 about the limit of proportionality of the spring?

(e) The student repeated the investigation with three more springs, K, L and M.

The results for these springs are given in Figure 4.

All three springs show the same relationship between the weight and extension.

What is that relationship?
Tick one box.
The extension increases non-linearly with the increasing weight.  

The extension is inversely proportional to the weight.  

The extension is directly proportional to the weight.  

(f) Which statement, A, B or C, should be used to complete the sentence? 

Write the correct letter, A, B or C, in the box below.

A a lower spring constant than  
B the same spring constant as  
C a greater spring constant than  

From Figure 4 it can be concluded that spring M has the other two springs.  

(Q5. (a) The diagram shows the horizontal forces acting on a swimmer.  

(i) The swimmer is moving at constant speed. 
Force T is 120 N. 
What is the size of force D?  

_________________________ N  

(ii) By increasing force T to 140 N, the swimmer accelerates to a higher speed. 
Calculate the size of the initial resultant force acting on the swimmer.  

________________________________________________________________________  
________________________________________________________________________  

Initial resultant force = _________________________ N  

(Total 7 marks)
(iii) Even though the swimmer keeps the force $T$ constant at 140 N, the resultant force on the swimmer decreases to zero. Explain why.

(b) A sports scientist investigated how the force exerted by a swimmer’s hands against the water affects the swimmer’s speed. The investigation involved 20 males and 20 females swimming a fixed distance. Sensors placed on each swimmer’s hands measured the force 85 times every second over the last 10 metres of the swim. The measurements were used to calculate an average force. The average speed of each swimmer over the last 10 metres of the swim was also measured.

The data from the investigation is displayed in the graph.

(i) What was the dependent variable in this investigation?

(ii) Explain one advantage of measuring the force 85 times every second rather than just once or twice every second.
(iii) Give one way in which the data for the male swimmers is different from the data for the female swimmers.

____________________________________________________________________________

(iv) Considering only the data from this investigation, what advice should a swimming coach give to swimmers who want to increase their average speed?

____________________________________________________________________________

(Total 10 marks)

Q6.

The diagram shows a simple machine for lifting water from a river.

(a) Calculate the turning force (moment) of the bucket of water.

(Show your working.)

____________________________________________________________________________

____________________________________________________________________________

Answer _____________________________ Nm (newton metre)

(b) What can you say about the size of downwards force the operator must use to balance the moment of the bucket of water?

(Explain your answer, using numbers if you can.)
Q7.
The diagram shows a crane which is loading containers onto a ship.

(a) Calculate the moment of the container which is being loaded.

Show clearly how you work out your answer and give the unit.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

Moment of the container = ____________________________________________  (3)

(b) Suggest and explain the purpose of the large concrete blocks.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

___________________________________________________________________  (3)

Q8.
The diagram shows a gardener using a steel bar to lift a tree stump out of the ground.
When the gardener pushes with a force of 300 N, the tree stump just begins to move.

(a) Use the equation in the box to calculate the moment produced by the 300 N force.

\[
\text{moment} = \text{force} \times \text{perpendicular distance from the line of action of the force to the axis of rotation}
\]

Show clearly how you work out your answer.

___________________________________________________________________
___________________________________________________________________

\[
\text{Moment} = \text{__________________________} \text{ newton metres}
\]

(2)

(b) Using a longer steel bar would have made it easier for the gardener to lift the tree stump out of the ground.

Explain why.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

___________________________________________________________________

(2)

(Total 4 marks)

Q9.

A spanner gives a turning effect to undo a nut.

(a) Complete the sentence.

The turning effect of a force is called the ________________________ of the force.

(1)

(b) The diagram shows a spanner being used.
Calculate the spanner’s turning effect in newton metres.

Show clearly how you work out your answer.

___________________________________________________________________
___________________________________________________________________

Turning effect = _______________ Nm (2)

(c) Give two ways in which you can increase the spanner’s turning effect.

1. _________________________________________________________________
2. _________________________________________________________________ (2)

(Total 5 marks)

Q10.

A student was asked to find the centre of mass of a thin sheet of card. The diagram shows the result of the student’s experiment. The student drew two lines onto the card. The centre of mass is where the two lines cross.

(a) Describe how the student found the correct positions to draw the two lines.

You may include a labelled diagram in your answer.
Q11.
Forces have different effects.

(a) (i) Use the correct answer from the box to complete the sentence.

\[
\begin{array}{ccc}
\text{slowing} & \text{stretching} & \text{turning} \\
\end{array}
\]

The moment of a force is the \underline{\hspace{2cm}}\hspace{2cm} effect of the force.

(1)

(ii) What is meant by the centre of mass of an object?

\underline{\hspace{2cm}}

(1)
(b) Some children build a see-saw using a plank of wood and a pivot. The centre of mass of the plank is above the pivot.

**Figure 1** shows a boy sitting on the see-saw. His weight is 400 N.

![Figure 1](image1.png)

Calculate the anticlockwise moment of the boy in Nm.

___________________________________________________________________
___________________________________________________________________

Anticlockwise moment = ____________________ Nm

(2)

(c) **Figure 2** shows a girl sitting at the opposite end of the see-saw. Her weight is 300 N.

![Figure 2](image2.png)

The see-saw is now balanced.

The children move the plank. Its centre of mass, M, is now 0.25 m from the pivot as shown in **Figure 3**.

![Figure 3](image3.png)
The boy and girl sit on the see-saw as shown in Figure 3.

(i) Describe and explain the rotation of the see-saw.

(ii) The boy gets off the see-saw and a bigger boy gets on it in the same place. The girl stays in the position shown in Figure 3. The plank is balanced. The weight of the plank is 270 N.

Calculate the weight of the bigger boy.

Weight of the bigger boy = ____________________ N

Q12.

Figure 1 shows a girl standing on a diving board.
(a) Calculate the moment of the girl's weight about Point A.

___________________________________________________________________
___________________________________________________________________

Moment = _________________________ newton metres

(2)

(b) **Figure 2** shows the girl standing at a different place on the diving board.

The support provides an upward force $F$ to keep the diving board balanced.

![Figure 2](image)

Complete the following sentence.

The diving board is not turning. The total clockwise moment is balanced by the total ________________________________ .

(1)

(c) **Figure 3** shows how the upward force $F$ varies with the distance of the girl from Point A.

![Figure 3](image)
(i) Use Figure 3 to determine the upward force \( F \) when the girl is standing at a distance of 3 metres from point \( A \).

Upward force \( F = \) _________________________ newtons

(1)

(ii) What conclusion should be made from Figure 3?

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

(1)

(Total 5 marks)

Q13.

Levers and hydraulic systems can act as force multipliers.

(a) Figure 1 shows a girl trying to lift a large rock using a long rod as a lever.

The girl is pushing down on the rod but is just unable to lift the rock.

Which of the following changes would allow her to lift the rock?

Tick (✓) two boxes.

<table>
<thead>
<tr>
<th>Change</th>
<th>Tick (✓)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Move the pivot away from the rock</td>
<td></td>
</tr>
<tr>
<td>Make the rod longer</td>
<td></td>
</tr>
<tr>
<td>Push the rod upwards</td>
<td></td>
</tr>
<tr>
<td>Push down on the rod with a greater force</td>
<td></td>
</tr>
</tbody>
</table>

(2)

(b) Liquids are used in hydraulic systems because they are virtually incompressible.

Explain how the spacing of particles in a liquid cause it to be virtually incompressible.

________________________________________________________________________
(c) **Figure 2** shows a man using a car jack to lift his car.

![Figure 2](https://isafx/iStock/Thinkstock)

**Figure 3** shows a simple diagram of a car jack.

![Figure 3](https://isafx/iStock/Thinkstock)

(i) The man pushes down with an effort force. This results in a much larger force acting upwards on the car.

Use information from **Figure 3** to explain how.
(ii) Which of the following statements about the forces in *Figure 3* is correct?

Tick (√) one box.

<table>
<thead>
<tr>
<th>Tick (√)</th>
</tr>
</thead>
<tbody>
<tr>
<td>The force acting on the car moves a greater distance than the effort force.</td>
</tr>
<tr>
<td>The force acting on the car moves less distance than the effort force.</td>
</tr>
<tr>
<td>The force acting on the car moves the same distance as the effort force.</td>
</tr>
</tbody>
</table>

(Total 9 marks)

Q14.

A student carries out an investigation using a metre rule as a pendulum.

(a) **Diagram 1** shows a metre rule.

![Diagram 1](image)

(i) Draw, on **Diagram 1**, an X to show the position of the centre of mass of the rule.

(1)

(ii) State what is meant by the ‘centre of mass of an object’.

(1)

(b) The student taped a 100 g mass to a metre rule.

She set up the apparatus as shown in **Diagram 2**.

She suspended the metre rule from a nail through a hole close to one end, so she could use the metre rule as a pendulum.

The distance d is the distance between the nail and the 100 g mass.

**Diagram 2**
(i) Draw, on Diagram 2, a Y to show a possible position of the centre of mass of the pendulum.

(1)

(ii) The student carried out an investigation to find out how the time period of the pendulum varies with \( d \).

Some of her results are shown in the table.

<table>
<thead>
<tr>
<th>( d ) in cm</th>
<th>First test</th>
<th>Second test</th>
<th>Third test</th>
<th>Mean value</th>
<th>Mean time for 1 swing in seconds</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.0</td>
<td>15.3</td>
<td>15.4</td>
<td>15.5</td>
<td>15.4</td>
<td>1.54</td>
</tr>
<tr>
<td>30.0</td>
<td>14.7</td>
<td>14.6</td>
<td>14.7</td>
<td>14.7</td>
<td>1.47</td>
</tr>
<tr>
<td>50.0</td>
<td>15.3</td>
<td>15.6</td>
<td>15.4</td>
<td>15.4</td>
<td>1.54</td>
</tr>
<tr>
<td>70.0</td>
<td>16.5</td>
<td>16.6</td>
<td>16.5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Complete the table.

You may use the space below to show your working.

__________________________________________________________________________

__________________________________________________________________________

(3)

(iii) *In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.*

Describe how the student would carry out the investigation to get the results in
the table in part (ii).

You should include:

- any other apparatus required
- how she should use the apparatus
- how she could make it a fair test
- a risk assessment
- how she could make her results as accurate as possible.

(c) A graph of the student’s results is shown below.
(i) Describe the pattern shown by the graph.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

(ii) The student thinks that the measurements of time for \( d = 10 \) cm might be anomalous, so she takes a fourth measurement.

Her four measurements are shown below.

\[
15.3 \text{ s} \quad 15.4 \text{ s} \quad 15.5 \text{ s} \quad 15.3 \text{ s}
\]

State whether you consider any of these measurements to be anomalous.

Justify your answer.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

(2)

(Total 16 marks)
Q15.  

(a) Use the correct answer from the box to complete the sentence.  

<table>
<thead>
<tr>
<th>balancing</th>
<th>stretching</th>
<th>turning</th>
</tr>
</thead>
</table>

A moment is the ________________ effect of a force.  

(1)

(b) Figure 1 shows how a lever can be used to lift a heavy rock.  

![Figure 1](image)

Calculate the moment of the weight of the rock about point P.  

___________________________________________________________________  

________________________________________________________  

Moment = _______________________ newton metres  

(2)

(c) Figure 2 shows three positions on the lever, A, B and C, where the person could have applied a force to lift the rock.  

![Figure 2](image)

Which position, A, B or C, needs the smallest force to lift the rock?  

Draw a ring around the correct answer.  

[ ] A  [ ] B  [ ] C  

Give the reason for your answer.  

___________________________________________________________________
Q16.

A drum is hit by a beater attached to a drumstick lever. The drumstick lever is attached to a foot-pedal by a chain, as shown below.

(a) State how the size of the force of the chain on the foot-pedal compares with the size of the force of the toe on the foot-pedal.

(b) The foot-pedal is pushed halfway down and held stationary.

The force of the toe and the force of the chain each create a moment which acts on the foot-pedal.

Compare the size and direction of the moments of the toe and the chain.

Tick (√) one box.

<table>
<thead>
<tr>
<th>Size</th>
<th>Direction</th>
<th>Tick (√)</th>
</tr>
</thead>
<tbody>
<tr>
<td>The moments are equal</td>
<td>same</td>
<td></td>
</tr>
<tr>
<td>The moments are equal</td>
<td>opposite</td>
<td></td>
</tr>
<tr>
<td>The moment of the force of the toe is greater</td>
<td>same</td>
<td></td>
</tr>
</tbody>
</table>

(c) How can the drummer create a greater moment about the pivot without increasing the force he applies?
Q17.

In a balancing game, wooden blocks are used to build a tower. The shape of the tower at the start of the game is shown in Figure 1. During the game, some of the blocks are taken out and put on top of the tower as shown in Figure 2. This causes the centre of mass of the tower to change.

(a) (i) State what is meant by the term ‘centre of mass’.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

(1)

(ii) Give two reasons why the tower in Figure 2 is less stable than the tower in Figure 1.

1. ____________________________________________________________

________________________________________________________________________

2. ____________________________________________________________

________________________________________________________________________

(2)

(b) Figure 3 shows a different arrangement for the wooden blocks.
A block was placed in position A and an identical block was placed in position B at the same time.

Explain why the tower did not fall over. You should include reference to moments in your answer.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

(2)
(Total 5 marks)

Q18.

Figure 1 shows the design of a playground ride.

![Figure 1](image)

A large wooden block rests on ropes. The ropes are attached to a metal frame. Children sit on the wooden block.

When the wooden block is moved to the left and released it moves to and fro.

When the wooden block returns to the point of release it has completed one cycle.

(a) Identify two possible hazards of the ride in Figure 1.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

(2)

(b) The designer of the ride wants to know if the ride has the same time period as a pendulum of the same length.

The designer used a model of the ride and a pendulum as shown in Figure 2.
The designer measured the time taken to complete 10 cycles for different lengths of both the model ride and the pendulum.

The results for the model ride are shown in Table 1.

### Table 1

<table>
<thead>
<tr>
<th>Length in metres</th>
<th>Time for 10 cycles in seconds</th>
<th>Mean time period in seconds</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>First time</td>
<td>Second time</td>
</tr>
<tr>
<td>0.100</td>
<td>6.36</td>
<td>6.37</td>
</tr>
<tr>
<td>0.150</td>
<td>7.76</td>
<td>7.74</td>
</tr>
<tr>
<td>0.200</td>
<td>8.97</td>
<td>8.99</td>
</tr>
</tbody>
</table>

The results for the pendulum are shown in Table 2.

### Table 2

<table>
<thead>
<tr>
<th>Length in metres</th>
<th>Time for 10 cycles in seconds</th>
<th>Mean time period in seconds</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>First time</td>
<td>Second time</td>
</tr>
<tr>
<td>0.250</td>
<td>10.00</td>
<td>10.04</td>
</tr>
<tr>
<td>0.300</td>
<td>10.99</td>
<td>11.01</td>
</tr>
<tr>
<td>0.350</td>
<td>11.88</td>
<td>11.83</td>
</tr>
</tbody>
</table>

(i) Complete Table 1, giving values to an appropriate number of significant figures.

(ii) The investigation already includes repeated readings.

Suggest one improvement that could be made to this investigation.
The designer reads in an Advanced Physics textbook that:

‘The square of the time period, \( T \), for a simple pendulum is proportional to its length, \( l \).’

\[
T^2 \propto l
\]

Would the model ride have the same time period as a simple pendulum of the same length?

Use one row of data from Table 1 and one row of data from Table 2 to work out your answer.

State your conclusion.

\(3\)

(c) The ride was redesigned and built to make it safer.

The wood was moving at maximum speed. The maximum kinetic energy of the wood was 180 J.

A parent applied a force to the wood and stopped it in a distance of 0.25 m.

Calculate the force required.

\[
\text{Force} = \underline{\quad} \text{N}
\]

\(3\)

\(\text{Total 12 marks}\)

Q19.

The diagram shows the passenger train on part of a rollercoaster ride.

(a) Which arrow shows the direction of the resultant force acting on the passenger train?

Put a tick (✓) in the box next to your choice.
For part of the ride, the maximum gravitational field strength acting on the passengers seems 3 times bigger than normal.

Normal gravitational field strength = 10 N/kg

(i) Calculate the maximum gravitational field strength that seems to act on the passengers during the ride.

Maximum gravitational field strength = _______________ N/kg

(ii) One of the passengers has a mass of 75 kg.

Calculate the maximum weight this passenger seems to have during the ride. Show clearly how you work out your answer.

Maximum weight = _______________ N

(Total 4 marks)
Q1.
(a) the forces are equal in size and act in opposite directions 1

(b) (i) forwards / to the right / in the direction of the 300 N force
   answers in either order 1

   accelerating 1

   (ii) constant velocity to the right 1

   (iii) resultant force is zero
   accept forces are equal / balanced 1

   so boat continues in the same direction at the same speed 1

   (iv) parallelogram or triangle is correctly drawn with resultant

   value of resultant in the range 545 N – 595 N
   parallelogram drawn without resultant gains 1 mark
   If no triangle or parallelogram drawn:
   drawn resultant line is between the two 300 N forces gains 1 mark
   drawn resultant line is between and longer than the two 300 N forces gains 2 marks 1

Q2.
(a) speed
   must be in correct order 1

   direction 1

   (b) | Quantity  | Scalar | Vector |
       |----------|--------|--------|
       | Momentum |        | ✓      |
       | Acceleration |        | ✓      |
Q3.

(a) (produces) a force from water on the boat in the forward direction

accept in the opposite direction
this must refer to the direction of the force not simply the boat moves forwards
an answer produces an (equal and) opposite force gains 1 mark

(b) (i) 1.5

allow 1 mark for correct substitution, ie \( \frac{16 - 4}{8} = \frac{12}{8} \) or \( 10 \)
provided no subsequent step shown
ignore sign

\[ \text{m/s}^2 \]

(ii) 102
or
their (b)(i) \times 68 correctly calculated
allow 1 mark for correct substitution, ie 1.5 \times 68
or their (b)(i) \times 68
provided no subsequent step shown

(iii) greater than
reason only scores if greater than chosen
need to overcome resistance forces
accept named resistance force
accept resistance forces act (on the water skier)
do not accept gravity

Q4.
(a) from K to L
(b) the same as
smaller than
correct order only
(c) 4 N
(d) the limit of proportionality is reached when a weight of 7N is added to the spring
accept any number from 6.8 to 7.2 inclusive
(e) the extension is directly proportional to the weight.
(f) C

Q5.
(a) (i) 120
(ii) 20
accept 140–their (a)(i) provided answer is not negative
(iii) as speed increases

drag force / water resistance / friction / \(D\) increases

(直至) \(D = 140\) N or (直至) \(D = T\)
forces balance is insufficient

(b) (i) (average) speed (of swimmer)

(ii) any two from:

- more data
  accept results for data
  do not accept more accurate data
- force may vary (a lot) / change
- give more reliable average
  ignore references to anomalies
  ignore accurate / precise

(iii) examples of acceptable responses:

- most / some females produce smaller forces
  do not accept all females produce smaller forces
- most / some males produce larger forces
  do not accept all males produce larger forces
- some females swim as fast as males but use a smaller force
- most of the faster swimmers are male
  do not accept all males swim faster
- most of the slower swimmers are female
  do not accept all females swim slower
- range of the (average) speed of males is smaller than the range of the (average) speed of females
- range of the (average) force of the males is greater than the range of the (average) force of the females

(iv) exert maximum (hand) force (throughout the swim / stroke)
accept (any method to) increase (hand) force
practise more is insufficient
(a) **evidence of moment = force \times distance**

or \(200 \times 1.5\)

\[gains \ 1 \ \text{mark}\]

**but** \(300\)

\[gains \ 2 \ \text{marks}\]

(b) **ideas that** smaller than load

\[gains \ 1 \ \text{mark}\]

**but** \(100 \ \text{N} \ or\) half the load

\[gains \ 2 \ \text{marks}\]

because applied further from pivot

\[gains \ 1 \ \text{mark}\]

**but** applied \(2 \times\) distance from pivot **or** evidence of balancing moments

\[gains \ 2 \ \text{marks}\]

(working for (b) shown in (a) gains credit – transfer mark)

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**Q7.**

(a) \(810 \ 000\)

\[allow \ 45 \ 000 \times 18 \ for \ 1 \ \text{mark}\]

newton-metres / Nm

(b) **any three** from:

*ignore references to force throughout*

- their weight / mass can be altered / adjusted

- so that the crane remains stable

  *allow does not topple*

- so that the (total) clockwise moment equals the (total) anticlockwise moment

  *do not allow just \textit{‘moments are equal’}*

- because not all containers are the same weight / mass

  *do not allow \textit{‘not all containers are the same size / volume’}*

- because not all containers will be / need to move the same distance (from the crane)

- to keep the centre of mass (of the upper crane and container) in/ above the base of the tower

- so that the crane remains in equilibrium/balanced
Q8.
(a) 360
   *allow 1 mark for correct substitution ie 300 × 1.2 provided no subsequent step shown*

(b) the force is applied further from the axis of rotation
   *accept pivot / (tree) stump for ‘axis of rotation’*

   or

   this increases the moment of the force
   increases the force on the (tree) stump

Q9.
(a) moment
   *or torque do not credit ‘leverage’*

(b) 4 (2)
   *either 0.20 × 20 (1) or allow ‘400’ (1)*

(c) use a longer spanner
   *or increases the perpendicular distance / length*

   or ‘fit a pipe over the (end of the) spanner (to lengthen it)’
   *note ‘lever’ refers to ‘spanner’*
   *note change the . . . (0)*
   *ignore references to wider / larger nut*

   use a greater force / pull
   *either order*

Q10. 
*Resource currently unavailable*

Q11.
(a) (i) turning
   *accept turning ringed in the box*

(ii) point at which mass (or weight) may be thought to be concentrated
   *accept the point from which the weight appears to act*
allow focused for concentrated

\textit{do not} accept most / some of the mass
\textit{do not} accept region / area for point

\textbf{(b)} \ 600 \ (Nm)

\begin{align*}
400 \times 1.5 \ & \text{gains 1 mark provided no subsequent steps shown} \\
\end{align*}

\textbf{(c)} \ (i) \ plank rotates clockwise

\begin{align*}
& \text{accept girl moves downwards} \\
& \textit{do not} accept rotates to the right
\end{align*}

(total) CM > (total) ACM

\begin{align*}
& \text{accept moment is larger on the girl's side} \\
\end{align*}

weight of see-saw provides CM

\begin{align*}
& \text{answer must be in terms of moment} \\
& \text{maximum of 2 marks if there is no reference to the weight of the see-saw}
\end{align*}

\textbf{(ii)} \ \ W = 445 \ (N)

\begin{align*}
W \times 1.5 = (270 \times 0.25) + (300 \times 2.0) \ & \text{gains 2 marks} \\
& \text{allow for 1 mark;} \\
& \text{total CM} = \text{total ACM either stated or implied} \\
& \text{or} \\
& (270 \times 0.25) + (300 \times 2.0) \\
& \text{if no other marks given}
\end{align*}

\begin{enumerate}
\item \ Q12.
\item \ (a) \ \ 3000

\begin{align*}
& \text{allow 1 mark for correct substitution, ie } 600 \times 5 \text{ provided no subsequent step} \\
& \end{align*}

\item \ \ (b) \ \ \text{anticlockwise moment}

\begin{align*}
& \text{must be both words} \\
& \end{align*}

\item \ \ (c) \ (i) \ \ 3400

\begin{align*}
& \text{allow 3.4 kilo (newtons)} \\
& \end{align*}

\item \ \ (ii) \ \ \text{as the distance (of the girl from point A) increases, force F increases}

\begin{align*}
& \text{allow gets bigger for increases} \\
& \text{force is (directly) proportional to distance will negate any correct response} \\
& \end{align*}
\end{enumerate}
Q13.
(a) make the rod longer
push down on the rod with a greater force

(b) particles are close together

so no room for more movement
dependent on 1st marking point

(c) (i) downward force produces pressure in liquid
reference to compression of liquid negates this mark

this pressure is the same at all points in a liquid
or
this pressure is transmitted equally through the liquid

and \( P = \frac{F}{A} \) or \( F = P \times A \)

area (at load) bigger (so force bigger)

(ii) the force acting on the car moves less distance than the effort force

[9]

Q14.
(a) (i) \( X \) placed at 50 cm mark

(ii) point at which mass of object may be (thought to be) concentrated

(b) (i) \( Y \) placed between the centre of the rule and the upper part of mass

(ii) 16.5

\[
\text{allow for 1 mark} \\
(16.5 + 16.6 + 16.5) / 3
\]

1.65

value consistent with mean value given
only penalise significant figures once

(iii) Marks awarded for this answer will be determined by the quality of communication as well as the standard of the scientific response. Examiners should apply a ‘best-fit’ approach to the marking.

0 marks
No relevant content
Level 1 (1 – 2 marks)
A description of a method which would provide results which may not be valid

Level 2 (3 – 4 marks)
A clear description of a method enabling some valid results to be obtained. A safety factor is mentioned

Level 3 (5 – 6 marks)
A clear and detailed description of experiment. A safety factor is mentioned. Uncertainty is mentioned

examples of the physics points made in the response:

additional apparatus
• stopwatch

use of apparatus
• measure from hole to centre of the mass
• pull rule to one side, release
• time for 10 swings and repeat
• divide mean by 10
• change position of mass and repeat

fair test
• keep other factors constant
• time to same point on swing

risk assessment
• injury from sharp nail
• stand topple over
• rule hit someone

accuracy
• take more than 4 values of \( d \)
• estimate position of centre of slotted mass
• small amplitudes
• discard anomalous results
• use of fiducial marker

(c) (i) initial reduction in \( T \) (reaching minimum value) as \( d \) increases

after 30 cm \( T \) increases for higher value of \( d \)

(ii) (no)

any two from:
• fourth reading is close to mean
• range of data 0.2 s / very small
• variation in data is expected
Q15.
(a) turning

(b) 420
   allow 1 mark for correct substitution, ie 1400 × 0.30 provided
   no subsequent step shown

(c) A
   reason only scores if A is chosen
   any one correct reason:
   the force is furthest away (from the pivot)
   accept distance (from the pivot) is the greatest
   accept it is further away (from the pivot)
   accept furthest away from the rock

Q16.
(a) (force on the chain is) smaller (than the force of the toe)

(b) Tick in middle box
   The moments are equal and opposite

(c) move the toe (up the pedal) away from the pivot

Q17.
(a) (i) the point where the mass is (thought to be) concentrated

(ii) the centre of mass is higher
     the base (area) is smaller / narrower

(b) (the blocks at A and B) create equal and opposite moments
    the resultant moment is zero
    accept (moments are in) equilibrium / balanced
    or
    the block at A creates an anti-clockwise moment (1)
    so this must be balanced by an equal clockwise moment from the block at B (1)
Q18.
(a) any two from:
• wood falls off ropes
• child falls off
• wood hits child standing at side.
  accepts any reasonable suggestion

(b) (i) 7.77

0.78
0.777 or 0.77 gain 1 mark
their mean value / 10 gains 1 mark

(ii) use longer lengths (so longer times)
or
do both with the same lengths (so comparison can be made)
timing more than 10 cycles is insufficient

(iii) 1 value of k from table 4
k values 3.969…
4.056…
4.05
k = \frac{T^2}{l}
allow full credit for an equivalent correct method
e.g. allow inverse of
k = \frac{l}{T^2} = 0.25

1 value of k from table 5
k values 4
4.03…
4.046
allow if average time for 10 cycles used

conclusion that matches student’s results

(c) 720 N

180 = F \times 0.25 gains 2 marks
work done = maximum kinetic energy gains 1 mark

Q19.
(a) correct box ticked
(b) (i) 30
ignore added units

(ii) 2250 or their (b)(i) × 75 correctly calculated
allow 1 mark for correct substitution ie 75 × 30 or their (b)(i) × 75 provided no subsequent step shown
an answer of 750 gains 1 mark only if answer to (b)(i) is 10