1 Measurement and uncertainties

1.1 Measurements in physics

Name: ……………………………….. Date: ………………………………..

**Estimation**

1. Estimate the area under the following graph.

![Graph](image)

2. Estimate the reading on the rule below.

![Rule](image)

3. Estimate the number of cars in a community of 6000 people where the average number of children per family is 1.8. Assume that almost every adult has a car.

4. The average person brushes his or her teeth twice a day. Estimate how many times a person has brushed his or her teeth by the age of 70.
There is an average of one fish per $5 \text{ m}^3$ in a lake that is approximately 5 metres deep. If a lake is approximately $58 \text{ m} \times 32 \text{ m}$ in a rectangular shape, estimate the number of fish in this lake.
Fundamental and derived units

1. A joule is equal to a newton metre and a newton is a kilogram metre per second$^2$. Write a joule in its fundamental units.

2. Re-write 25 m/s in a preferable way.

3. A watt is equal to a joule per second. Write a watt in its fundamental units.

4. A watt is equal to a volt multiplied by an ampere. Write a volt in its fundamental units.

5. Electric charge (units are coulombs) is equal to electric current multiplied by time. Write a coulomb in its fundamental units.

6. A farad is equal to a coulomb per volt. Write a farad in its fundamental units.

7. An ohm is a volt per amp. Write an ohm in its fundamental units.

8. The units of electrical conductance are equal to the reciprocal of ohms. Write the fundamental units of electrical conductance.

9. A tesla equals a volt second per metre$^2$. Write a tesla in its fundamental units.

10. What is the unit of amount of substance?
1 Measurement and uncertainties

1.1 Measurements in physics

Name: ……………………………….
Date: ………………………………..

Orders of magnitude

1 State the order of magnitude of each of the following:
   a 565 ...........................................................................................................................
   b 29 ...........................................................................................................................
   c 0.000 656 ................................................................................................................
   d 248 789 ..................................................................................................................
   e 0.1 ...........................................................................................................................

2 Determine the orders of magnitude in each of the following:
   a 43 ÷ 26 = ...................................................................................................................
   b 892 ÷ 16 = ..............................................................................................................
   c 2555 ÷ 0.2365 = .......................................................................................................
   d 2.23 × 15.67 = .......................................................................................................  
   e (1.6 × 10^4) × (7.6 × 10^6) = .......................................................................................

3 A pile of sand has a width that ranges from 38 m to 41 m and a length that is approximately 125 m. If the depth varies from 8.8 m to 9.1 m, what is the order of magnitude of the volume?

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4 325 pieces of steel, 6.5 cm thick on average, are vertically stacked. What is the order of magnitude of the total thickness?

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5 Solve and state the order of magnitude: 81 μm + 96 cm + 21 pm + 148 mm

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1 Measurement and uncertainties

1.1 Measurements in physics

Name: ……………………………….
Date: ……………………………….

Scientific notation and metric multipliers

1 Express the following in scientific notation.

a  237 ........................................................................................................................................

b  37529035903475 ................................................................................................................

c  0.00354 ..........................................................................................................................

d  0.02020202 .......................................................................................................................

2 Convert the following to decimal form.

a  2.369 \times 10^6 ...................................................................................................................

b  7.85 \times 10^{-5} ................................................................................................................

3 Solve the following.

a  1.25 \times 10^5 + 2.8 \times 10^4 = .........................................................................................

b  2.36 \times 10^3 \times 4.51 \times 10^3 = .........................................................................................

c  (2.22)^4 = ........................................................................................................................

d  1.26 \times 10^2 / 385 = .........................................................................................................

4 Express the following in scientific notation.

a  13 \mu m + 18 \mu m = ........................................................................................................

b  2.5 \text{Mm} + 5600 \text{km} = ..............................................................................................
1 Measurement and uncertainties

1.1 Measurements in physics

Name: ...........................................  Date: ...........................................

**Significant figures**

1. State the number of significant figures in the following.
   a. 205 .................................................................................................................................
   b. 1000 .................................................................................................................................
   c. 0.023 .................................................................................................................................
   d. 0.020 .................................................................................................................................
   e. 2.30 \times 10^5 .....................................................................................................................

2. Solve the following.
   a. \sin 35 = ............................................................
   b. 14.28 + 5.13 + 2.222 = ..............................................................
   c. 16.25 ÷ 0.09 = ..............................................................
   d. 16 \text{ nm} \times 14 \text{ pm} = ..............................................................
   e. 5.62 \times 10^{12} ÷ 2.717 \times 10^5 = ..............................................................

3. Round 0.00350681 to:
   a. 1 significant figure ........................................................................................................
   b. 2 significant figures ........................................................................................................
   c. 3 significant figures ........................................................................................................
   d. 4 significant figures ........................................................................................................
   e. 5 significant figures ........................................................................................................
1 Measurement and uncertainties

1.2 Uncertainties and errors

Name: ................................................. Date: .................................................

Error bars

1 A particular reading in an experiment shows $s = 5.2 \pm 0.1$ m when $t = 0.32 \pm 0.05$ s. What are the maximum and minimum values for $s$ and $t$?

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

2 Show this range in a sketch.

3 Draw a line of best fit on the graph below.
1.2 Uncertainties and errors

Name: ……………………………….
Date: ……………………………….

Random and systematic errors

1. Gerald is not happy with the results of an experiment. He knows what the actual value of his recorded data should be. The teacher says that there may be a systematic error. He decides to perform more trials with the same equipment using the same techniques. He does not check the equipment for calibration. Would this eliminate the systematic errors? Explain your answer.

2. A student measures the width of an object several times and records the following data: 2.3 cm, 2.4 cm, 2.2 cm, 2.3 cm, 2.3 cm, 2.2 cm, and 2.8 cm. He decides to represent his data the following way:

\[
2.3 + 2.4 + 2.2 + 2.3 + 2.3 + 2.2 + 2.8 = 16.5
\]

\[
16.5 ÷ 7 = 2.357 \text{ cm}
\]

\[
(2.8 – 2.2) ÷ 2 = 0.3 \text{ cm}
\]

Therefore, the average value is \(2.4 ± 0.3\) cm. A teacher tells the student that his report should read \(2.3 ± 0.1\) cm. How did the teacher get this result and what type of error did the student commit?
1 Measurement and uncertainties

1.2 Uncertainties and errors

Name: ............................................ Date: ............................................

Absolute, fractional, and percentage uncertainties

1  a  What is the absolute uncertainty for the following measurements?

5.8 cm, 5.6 cm, 5.7 cm, 5.4 cm, 5.4 cm, 5.6 cm

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

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

b  Determine the fractional uncertainty in part a.

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

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

c  Determine the percentage uncertainty in part a.

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

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

2  The first length measured in a laboratory experiment is 2.5 ± 0.1 m and the second length 3.4 ± 0.1 m.

a  What is the sum of the lengths?

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

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

b  What is the difference in the lengths?

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

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

c  What is the percentage uncertainty in each a and b?

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

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

3  The first length measured in a laboratory is 2.9 m ± 3.4% and the second length 5.4 m ± 1.9%

a  What is the sum of the lengths?

.............................................................................................................................
b What is the difference in the lengths?
...............................................................................................................................
............................................................................................................................... 

c What is the percentage uncertainty in each a and b?
...............................................................................................................................
............................................................................................................................... 

4 What is the area of a rectangle measuring 1.2 ± 0.1 m and 1.7 ± 0.1 m?
...............................................................................................................................
............................................................................................................................... 

5 What is the area of a rectangle measuring 3.8 m ± 2.6% and 1.6 m ± 6.3%?
...............................................................................................................................
............................................................................................................................... 

6 Evaluate (1.5 ± 0.2 m)³.
...............................................................................................................................
............................................................................................................................... 

7 If $H^3 = a + b$ and the uncertainty in $a$ is 15% and $b$ is 6% when $H = 1.25$, find the uncertainty in $H$.
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1 Measurement and uncertainties

1.2 Uncertainties and errors

Name: .............................................. Date: ..............................................

Uncertainty of gradient and intercept

1 Use the following graph to state the gradient and $y$-intercept (with uncertainties). The values for time have 2 significant figures and no error bars shown and the values for distance have 2 significant figures with an uncertainty of $\pm 0.2$ m.

![Graph 1](image1)

2 Use the following graph to state the gradient and $y$-intercept (with uncertainties). The values for time have 2 significant figures and no error bars shown and the values for distance have 2 significant figures with an uncertainty of $\pm 0.2$ m.

![Graph 2](image2)
1. Which of the following pairs contains one fundamental and one derived unit?
   A. ampere; kilogram
   B. ampere; coulomb
   C. joule; newton
   D. joule; coulomb

2. The current, \( I \), through a resistor is measured with a digital ammeter to be
   \( 0.10 \) A. The uncertainty in the calculated value of \( I^2 \) will be
   A. \( 1 \% \)
   B. \( 2 \% \)
   C. \( 5 \% \)
   D. \( 20 \% \)

3. Which of the following will reduce random errors in an experiment?
   A. Using an instrument having a greater precision
   B. Checking the calibration of the instrument used
   C. Checking for zero error on the instrument used
   D. Repeating readings

4. A body accelerates from rest with a uniform acceleration \( a \) for a time \( t \). The uncertainty in \( a \) is \( 8 \% \) and the uncertainty in \( t \) is \( 4 \% \). The uncertainty in the speed is
   A. \( 32 \% \)
   B. \( 12 \% \)
   C. \( 8 \% \)
   D. \( 2 \% \)

5. Which of the following lists two scalar quantities?
   A. emf, momentum
   B. emf, weight
   C. impulse, kinetic energy
   D. magnetic flux, kinetic energy

6. The current in a resistor is measured as \( 2.00 \pm 0.02 \) A. Which of the following correctly identifies the absolute uncertainty and the percentage uncertainty in the current?
   
<table>
<thead>
<tr>
<th>Absolute uncertainty</th>
<th>Percentage uncertainty</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. ± 0.02 A</td>
<td>±1 %</td>
</tr>
<tr>
<td>B. ± 0.01 A</td>
<td>± 0.5 %</td>
</tr>
<tr>
<td>C. ± 0.02 A</td>
<td>± 0.01 %</td>
</tr>
<tr>
<td>D. ± 0.01 A</td>
<td>± 0.005 %</td>
</tr>
</tbody>
</table>

7. Which of the following is equivalent to the joule?
   A. \( N \) m²
   B. \( N \) m²
   C. \( \text{kg m s}^{-2} \)
   D. \( \text{kg m}^2 \) s⁻²

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8. Two lengths, \( a \) and \( b \), are measured to be 51\( \pm \)1 cm and 49\( \pm \)1 cm respectively. In which of the following quantities is the percentage uncertainty the largest?
A. \( a + b \)
B. \( a - b \)
C. \( a \times b \)
D. \( \frac{a}{b} \)

9. Which of the following is a valid statement?
A. A measurement that is not precise can be accurate.
B. A measurement that is precise is always accurate.
C. A measurement that is not precise will always be inaccurate.
D. Repeated measurements will always increase accuracy and precision.  

10. The volume \( V \) of a cylinder of height \( h \) and radius \( r \) is given by the expression

\[
V = \pi r^2 h.
\]

In a particular experiment, \( r \) is to be determined from measurements of \( V \) and \( h \).

The uncertainties in \( V \) and in \( h \) are as shown below.

<table>
<thead>
<tr>
<th></th>
<th>±7 %</th>
</tr>
</thead>
<tbody>
<tr>
<td>( V )</td>
<td></td>
</tr>
<tr>
<td>( h )</td>
<td>±3 %</td>
</tr>
</tbody>
</table>

The approximate uncertainty in \( r \) is
A. 10 %.
B. 5 %.
C. 4 %.
D. 2 %.  

(1)
1. The photograph below shows a magnified image of a dark central disc surrounded by concentric dark rings. These rings were produced as a result of interference of monochromatic light.

The graph below shows how the ring diameter $D$ varies with the ring number $n$. The innermost ring corresponds to $n = 1$. The corresponding diameter is labelled in the photograph. Error bars for the diameter $D$ are shown.

**a)** State one piece of evidence that shows that $D$ is not proportional to $n$.  

........................................................................................................................................ (1)

**b)** On the graph above, draw the line of best-fit for the data points.  

**c)** It is suggested that the relationship between $D$ and $n$ is of the form $D = cn^p$ where $c$ and $p$ are constants.
Explain what graph you would plot in order to determine the value of \( p \).

………………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………… (3)

d) Theory suggests that \( p = \frac{1}{2} \) and so \( D^2 = kn \) (where \( k = c^2 \)).

A graph of \( D^2 \) against \( n \) is shown below. Error bars are shown for the first and last data points only.

(i) Using the first graph, calculate the percentage uncertainty in \( D^2 \), of the ring \( n = 7 \).
……………………………………………………………………………………………………… (2)

(ii) Based on the second graph, state one piece of evidence that supports the relationship \( D^2 = kn \).
……………………………………………………………………………………………………… (1)

(iii) Use the second graph to determine the value of the constant \( k \), as well as its uncertainty.
……………………………………………………………………………………………………… (4)

(Total 13 marks)
2. A student performs an experiment with a paper toy that rotates as it falls slowly through the air. After release, the paper toy quickly attains a constant vertical speed as measured over a fixed vertical distance.

The aim of the experiment was to find how the terminal speed of the paper toy varies with its weight. The weight of the paper toy was changed by using different numbers of paper sheets in its construction.

The graph shows a plot of the terminal speed $v$ of the paper toy (calculated from the raw data) and the number of paper sheets $n$ used to construct the toy. The uncertainty in $v$ for $n = 1$ is shown by the error bar.

a) The fixed distance is 0.75 m and has an absolute uncertainty of 0.01 m. The percentage uncertainty in the time taken to fall through the fixed distance is 5%.
(i) Calculate the absolute uncertainty in the terminal speed of the paper toy for \( n = 6 \).

.......................................................................................................................................................................................................................................................... (3)

(ii) On the graph, draw an error bar on the point corresponding to \( n = 6 \). (1)

b) On the graph, draw a line of best-fit for the data points. (1)

c) The student hypothesizes that \( v \) is proportional to \( n \). Use the data points for \( n = 2 \) and \( n = 4 \) from the graph opposite to show that this hypothesis is incorrect.

.......................................................................................................................................................................................................................................................... (3)

(Total 8 marks)

3. This question is about liquid flow.

The diagram shows a storage container for liquids.

![Diagram of container](image)

The container is filled from above. The distance between the base of the container and the ground is \( h_0 \).
The container, which is initially empty, is then filled at a constant rate. The height \( h \) of the liquid surface above the ground is measured as a function of time \( t \). The results of the measurements are shown plotted below.

a) Draw a best-fit line for the data.  

b) It is hypothesized that \( h \) is directly proportional to \( t \). State and explain whether this hypothesis is correct for the periods

(i) \( t = 0 \) to \( t = 120 \) s.

(ii) \( t > 120 \) s.
c) Use data from the graph to determine the value of $h_0$.

……………………………………………………………………………………………………………………………. (2)

d) The area of the base of the container is 1.8 m$^2$. Deduce that the volume of liquid entering the storage container each second is approximately $0.02$ m$^3$ s$^{-1}$.

……………………………………………………………………………………………………………………………. (3)

e) The container is completely filled after 850 s. Calculate the total volume of the container.

……………………………………………………………………………………………………………………………. (1)

(Total 9 marks)
2 Mechanics

2.1 Motion

Name: ………………………………
Date: ………………………………

Motion worksheet
For this worksheet use \( g = 9.81 \text{ ms}^{-2} \).

1 A ball rolls down a 445 m slope from rest. If it accelerates at a rate of \( 3.16 \text{ ms}^{-2} \), determine the time it takes to reach the bottom of the slope and the ball’s final velocity.

2 How far does a car travel in 45 seconds if it has an acceleration of \( 0.32 \text{ ms}^{-2} \)? Assume that it starts from rest.

3 A toy car starts from rest and accelerates at a uniform rate of \( 4.0 \text{ ms}^{-2} \) for 3.0 seconds. It then maintains a uniform speed for 12.0 seconds. Finally it takes 6.0 seconds to decelerate uniformly to rest. Find the total distance travelled and the average speed of the entire trip.
4 A car travels 25.0 km of a 50.0 km trip at an average speed of 40.0 km/h. It travels the second half of its journey at an average speed of 80.0 km/h. A truck makes the same trip but spends half of its time at an average speed of 40.0 km/h and the other half of its time at an average speed of 80.0 km/h. Which vehicle got there in the shortest period of time? Show your work.

5 A speeding car is travelling at a constant speed of 44 m/s when it passes a stationary police car. The police car immediately accelerates uniformly from rest at a rate of 2.2 m/s². If the car does not slow down and the police officer maintains the rate of acceleration, how long will it take the police car to catch the speeding car?

6 Two balls are 8.0 metres apart and moving directly towards each other. If the first ball is moving at a speed of 2.5 m/s with respect to the ground and the second ball 3.5 m/s with respect to the ground, where will they collide?

7 A helicopter is ascending at a constant speed of 12 m/s and drops a package from a height of 64 m. How long will it take the package to reach the ground? Assume there is no air resistance.
8 Use this graph to determine the following:

![Graph showing velocity over time]

a the acceleration during the first 8 seconds.

b the displacement of the whole trip.

c the average velocity of the whole trip.

9 A football is kicked from the ground with an initial speed of 16 ms\(^{-1}\) at an angle of 24° to the horizon. At what two times will the ball have a height of 1.0 m? Assume the kick happens at \(t = 0\) s.

10 A rock is thrown from the top of a 36 m high cliff with an initial speed of 12 ms\(^{-1}\) at an angle of 52° to the horizon. How long will it take the rock to reach the bottom of the cliff?
2 Mechanics

2.2 Forces

Name: ........................................ Date: ........................................

Forces worksheet

1. A stationary 16 kg mass moves a distance of 84 metres in 14 seconds when a horizontal force is applied. If the level surface is frictionless, determine the applied force.

2. A 15 kg box is pushed with a constant horizontal force of 85 N along a level surface. If the box moves with a uniform velocity of 6.0 ms\(^{-1}\), how much net force is required to accelerate it uniformly to 12 ms\(^{-1}\) in 2.0 s?

3. The following system is in equilibrium. What is the mass of the object?

4. A constant force of 245 N is applied at a 48.2° angle to a mass of 62.1 kg as shown below. If the mass moves at a constant speed of 3.28 ms\(^{-1}\), determine its coefficient of dynamic friction.
5 A mass of 6.3 kg is held on an inclined plane that has an angle of 2.4° with the horizontal. If the coefficient of static friction is 0.032, will the mass slide down the plane when released?

![Diagram of a mass on an inclined plane]

6 Forces of 4.0 N and 6.5 N act on the 25 kg mass shown below. Find its acceleration.

![Diagram of forces acting on a 25 kg mass]
Topic 2.1a Kinematics Problems

Conceptual Questions

(These questions are not in an IB style but instead designed to check your understanding of the concept of this topic. You should try your best to appropriately communicate your answer using prose)

1. Can an object have zero velocity and nonzero acceleration at the same time? Give examples.

2. Can the velocity of an object be negative when its acceleration is positive? What about vice-versa?

3. Can an object be increasing in speed as its acceleration decreases? If so, give an example. If not, explain.
Calculation-based Questions

1. A car accelerates from 13m/s to 25m/s in 6.0s. What was its acceleration? How far did it travel in this time? Assume constant acceleration.

   [2 marks]

2. A car slows down from 23m/s to rest in a distance of 85m. What was the acceleration, assumed constant?

   [1 mark]

3. Estimate how long it took King Kong to fall straight down from the top of the Empire State Building (380m high) and his velocity just before he touched the ground. Ignore air resistance.

   [2 marks]

4. A stone is thrown vertically upward with a speed of 18.0m/s. How fast is it moving when it reaches a height of 11.0m and how long is required to reach this height? Why are there two answers?

   [3 marks]
5. A stone is thrown vertically upward with a speed of 12.0 m/s from the edge of a cliff 70.0 m high. How long does it take to reach the bottom of the cliff and what is its speed before hitting? What was the total distance that it traveled? Ignore air resistance.

[3 marks]
1. The graph below shows the velocity of a train as a function of time.

![Graph showing velocity vs. time]

a. At what time was its velocity the greatest?

b. During which periods, if any, was the velocity constant?

c. During what periods, if any, was the acceleration constant?

d. When was the magnitude of the acceleration the greatest?

[4 marks]

Estimate the distance the object travelled

e. during the first minute and;

f. in the second minute

[2 marks]
2. The position of a rabbit along a straight tunnel as a function of time is plotted below. What is the instantaneous velocity
   a. at $t = 10.0\text{s}$ and,
   b. at $t = 30.0\text{s}$?

What is the average velocity
   c. between $t = 0$ and $t = 5.0\text{s}$,
   d. between $t = 25.0\text{s}$ and $t = 30.0\text{s}$ and,
   e. between $t = 40.0\text{s}$ and $t = 50.0\text{s}$?
3. A certain type of automobile can accelerate approximately as shown in the velocity – time graph as shown below. (The short flat spots in the curve represent shifting of the gears.)

Estimate the average acceleration when it is in
a. first,
b. third,
c. fifth gear.
d. What is its average acceleration through the first four gears? [4 marks]
Calculation-based Questions

1. A car accelerates from 13m/s to 25m/s in 6.0s. What was its acceleration? How far did it travel in this time? Assume constant acceleration.
   [2 marks]

2. A car slows down from 23m/s to rest in a distance of 85m. What was the acceleration, assumed constant?
   [1 mark]

3. Estimate how long it took King Kong to fall straight down from the top of the Empire State Building (380m high) and his velocity just before he touched the ground. Ignore air resistance.
   [2 marks]
4. A stone is thrown vertically upward with a speed of 18.0 m/s. How fast is it moving when it reaches a height of 11.0 m and how long is required to reach this height? Why are there two answers?

[3 marks]

5. A stone is thrown vertically upward with a speed of 12.0 m/s from the edge of a cliff 70.0 m high. How long does it take to reach the bottom of the cliff and what is its speed before hitting? What was the total distance that it traveled? Ignore air resistance.

[3 marks]
Topic 2.1d Projectile Motion Problems

Conceptual Questions
(These questions are not in an IB style but instead designed to check your understanding of the concept of this topic. You should try your best to appropriately communicate your answer using prose)

1. Two cannon balls A and B are fired from the ground with identical initial speeds, but with $\theta_A$ larger than $\theta_B$. (a) Which cannonball reaches a higher elevation? (b) which stays longer in the air? (c) Which travels farther?

2. A projectile is launched at an angle of 30° to the horizontal with a speed of 30m/s. How does the horizontal component of its velocity 1.0s after launch compare with its horizontal component of velocity 2.0s after launch?

Calculation Based

3. A tiger leaps horizontally from a 6.5m high rock with a speed of 3.5m/s. How far from the base of the rock will she land?

4. A diver running 1.8m/s dives out horizontally from the edge of a vertical cliff and 3.0s later reaches the water below. How high was the cliff and how far from its base did the diver hit the water?
5. A football is kicked at ground level with a speed of 18.0 m/s at an angle of 35.0° to the horizontal. How much later does it hit the ground?

6. A projectile is fired with an initial speed of 65.2 m/s at an angle of 34.5° above the horizontal on a long flat firing range. Determine (a) the maximum height reached by the projectile, (b) the total time in the air, (c) the total horizontal distance covered (that is the range), and (d) the velocity of the projectile 1.50 s after firing.

7. A projectile is shot from the edge of a cliff 125 m above ground level with an initial speed of 65.0 m/s at an angle of 37.0° with the horizontal, as shown below. (a) Determine the time taken by the projectile to hit point P at ground level. (b) Determine the range X of the projectile as measured from the base of the cliff. At the instant just before the projectile hits point P, find (c) the horizontal and the vertical components of its velocity, (d) the magnitude of the velocity, and (e) the angle made by the velocity vector with the horizontal. (f) Find the maximum height above the cliff top reached by the projectile.
1. A net force of 265N accelerates a bike and rider at 2.30m/s². What is the mass of the bike and the rider together? [1 mark]

2. What is the weight of a 76kg astronaut
   a. on Earth
   b. on the Moon (g = 1.7m/s²)
   c. on Mars (g = 3.7m/s²)
   d. in outer space traveling with constant velocity? [4 marks]

3. What is the average force required to stop a 1100-kg car in 8.0s if the car is travelling at 95km/h? [3 marks]

4. What is the average force needed to accelerate a 7.00g pellet from rest to 125m/s over a distance of 0.800m along the barrel of the rifle? [2 marks]
5. A 0.140 kg baseball traveling at 35.0 m/s strikes the catcher’s mit, which, in bringing the ball to rest, recoils backward 11.0 cm. What was the average force applied by the ball on the glove?

[2 marks]
Conceptual Questions

(These questions are not in an IB style but instead designed to check your understanding of the concept of this topic. You should try your best to appropriately communicate your answer using prose)

1. Why does a child, sat in a toy wagon, seem to fall backward when you give the wagon a sharp pull forward?

2. If the acceleration of an object is zero, are no forces acting on it? If only one force acts on the object, can the object have zero acceleration? Can it have zero velocity? Explain.

3. If you walk along a log floating on a lake, why does the log move in the opposite direction?
1. Arlene is to walk across a “high-wire” strung horizontally between two buildings 10.0m apart. The sag in the rope when she is at the mid-point is 10.0° as shown. If her mass is 50.0kg, what is the tension in the rope at this point? [2 marks]

2. A box weighing 77.0N rests on a table. A rope tied to the box runs vertically upward over a pulley and a weight is hung from the other end. Determine the force that the table exerts on the box if the weight hanging on the other side of the pulley weighs
   a. 30.0N
   b. 60.0N
   c. 90.0N

   (Hint: You should sketch a free-body diagram for the general case) [4 marks]
3. A window washer pulls herself upward using a bucket-pulley system as shown.
   a. Sketch a free-body diagram showing the force of gravity and the force exerted by the rope (tension).
   b. How hard must she pull downward to raise herself slowly at constant speed?
   c. If she increases this force by 15%, what will her acceleration be?

Assume the mass of the person and the bucket is 65kg.

[4 marks]
4. The diagram below shows a block (mass $m_1$) on a smooth horizontal surface, connected by a thin cord that passes over a pulley to a second block ($m_2$), which hangs vertically.

   a. Draw a free-body diagram for each block, showing the force of gravity on each, the force (tension) exerted by the cord, and any normal force.
   b. Apply Newton’s second law to find formulas for the acceleration of the system and for the tension in the cord. Ignore friction and the masses of the pulley and cord.

[3 marks]