Year 12 Mechanics Revision Booklet

Relationships:

$v = \frac{\Delta d}{\Delta t}$	$a = \frac{\Delta v}{\Delta t}$	$p = mv$ $E_p = \frac{1}{2}kx^2$	$\Delta p = F\Delta t$ $E_k = \frac{1}{2}mv^2$
$v_f = v_i + at$	$d = v_i t + \frac{1}{2}at^2$	$W = Fd$	$P = \frac{W}{t}$
$d = \frac{v_i + v_f}{2}t$	$v_f^2 = v_i^2 + 2ad$	$F = ma$	$\tau = Fd$
$a_c = \frac{v^2}{r}$	$F = -kx$	$F_c = \frac{mv^2}{r}$	$\Delta E_p = mg\Delta h$

Section A: Basics

1. Fill the tables below:

Quantity	Symbol	Unit	Unit Symbol
Velocity	v	Meters per second	ms^{-1}
Distance			
Time			
Force			
Gravitational Energy			
Kinetic Energy			
Work			
Power			
Mass			
Torque			
Acceleration			

Multiplier	Std. Form	Prefix
1/1000000000		
1/1000000		
1/1000		
1000	10^3	k
1000000		
1000000000		
1000000000000		

2. What do the following things stand for?

i) The 'F_c' in $F_c = mv^2/r$

ii) The 'k' in $F = -kx$

iii) The 'a_c' in $a_c = v^2/r$

iv) The 'v_f' in $v_f^2 = v_i^2 + 2ad$

v) The 'ΔE_p' in $\Delta E_p = mg\Delta h$

3. Calculate the following **to the correct number of significant figures**

i) The momentum of a 62kg object moving at $3.25ms^{-1}$ ($p = mv$)

ii) The Net Force on a 2.0kg object accelerating at $0.2ms^{-2}$ ($F = ma$)

iii) The average speed of a particle that moves 0.34μm in 12ns ($v_{ave} = \Delta d/\Delta t$)

Part B: Force and Motion

1. Calculate the following. Do **not** use the formula $v = \Delta d/\Delta t$ for these calculations.

i) The final speed of an object that accelerates from rest for 8 seconds with an acceleration of $0.3ms^{-2}$

ii) The time taken for an object to travel 6m, if it begins at $0.4ms^{-1}$ and finishes at $0.7ms^{-1}$.

iii) The initial speed of an object that accelerated at $0.2ms^{-2}$, travelled 11m and ended up with a velocity of $2.2ms^{-1}$.

2. A falling pebble has a mass of 67g and experiences an upward drag force of 0.4N

i) Calculate the weight of the pebble.

ii) Calculate the net force of the pebble.

iii) Calculate the acceleration of the pebble.

iv) Eventually, the pebble falls at a constant speed. Explain why. Use the terms **weight, drag, net force, terminal velocity.**

v) If the Drag force is given by $F = 0.2v^2$ then calculate the terminal velocity.

4. Consider the force diagrams below:

Diagram one

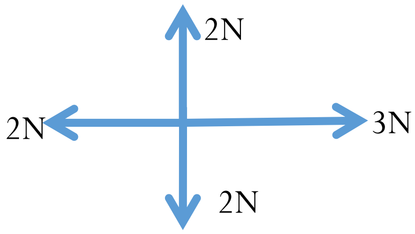


Diagram two

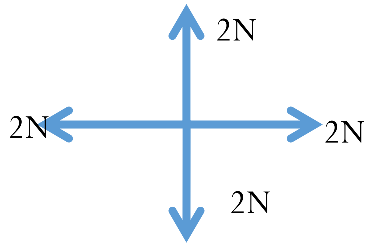
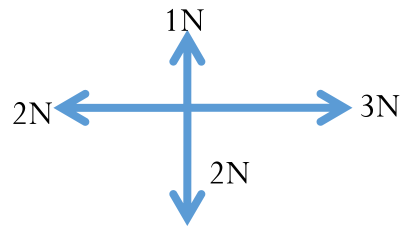


Diagram three



i) For each diagram, decide which of the following situations are **possible**

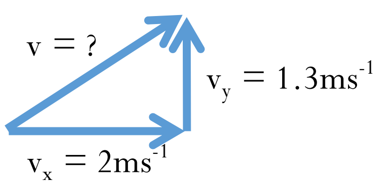
A: Moving fully to the left at a constant speed
B: Moving fully to the right at a constant speed
C: Moving fully to the left and speeding up
D: Moving fully to the left and slowing down
E: Moving fully to the right and speeding up
F: Moving fully to the right and slowing down

ii) For each diagram, calculate the **net** force. Remember that Force is a vector!

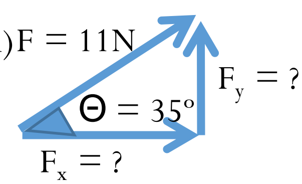
<u>Part C: Vectors</u>

1. Calculate the **magnitude and direction** of the following vectors. Calculate the direction as an angle from the horizontal.

i)



ii)



iii) $p_i = 16kgms^{-1}$ east
$p_f = 11\ kgms^{-1}$ south
$\Delta p = ?$

2. Marcus pushes a lawnmower forwards (horizontally) by applying a force of 32N at an angle of 21° *downwards from the horizontal.*

i) Draw a diagram to show this situation

ii) Calculate the work done by Marcus if he pushes the lawnmower for 17m.

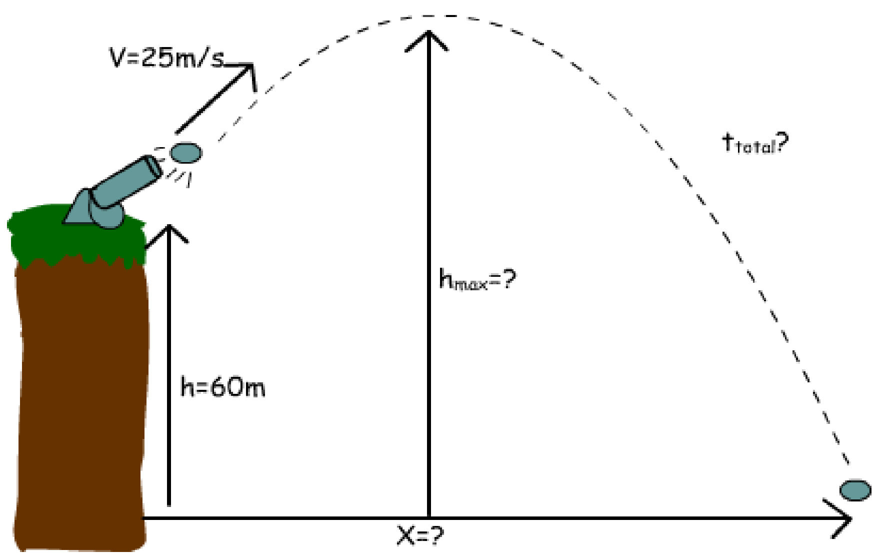
Challenge question: By what % does Marcus increase the support force from the ground on the 50kg mower by his push?

Part D: Projectile motion.

1. Harry hits a golf ball. It is in the air for 6 seconds and travels 230m.

i) What is the horizontal acceleration?
ii) What is the horizontal velocity?
iii) What is the vertical acceleration?
iv) How long does it take for the ball to reach the top of its flight, after Harry hits it?
v) What is the vertical velocity at the top of the flight?
vi) How high does the ball go?
vii) What was the initial vertical velocity?
viii) What was Harry's club speed? (i.e. what is the magnitude of the balls initial velocity?)
ix) At what angle did Harry hit the ball?

2.



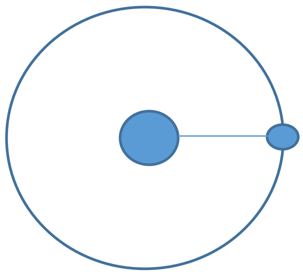
The launch angle is 45°. How far does the cannonball go?

Part E: Circular Motion

1. A 650kg Formula 1 car moves around a circle with radius 11m at a speed of 240kmh^{-1}.

i) Calculate the centripetal acceleration and the centripetal force.
ii) State the direction of this force.
iii) Explain what provides this force.

2. The diagram below shows a bird's eye view of a hammer thrower at the Olympics. The Olympian is in the act of swinging the hammer anti-clockwise (looking down – but somebody has sabotaged their campaign and tampered with the wire! At the instant pictured, the hammer has reached a speed of $18ms^{-1}$, the 0.9m long wire snaps, and the 7kg hammer goes flying off.



i) What direction does the hammer go?
ii) What direction was the tension force in the string just before it broke?
iii) At what Tension did the string break?
iv) An un-tampered with wire can handle a tension of 9500N. At what speed would this wire break?
v) The hammer was 1.7m off the ground when it snapped. How far did it go?

<u>Part F: Springs</u>

1. A spring has a spring constant of $23Nm^{-1}$.

i) What is the restoring force felt when the spring has been stretched 4cm?
ii) If the spring is stretched to the left, what direction is this restoring force acting?
iii) How much energy is stored in the spring at this point?

2. What is the spring constant of the spring in a Force Meter that is stretched 2cm by 250g of hanging mass?

3. At the Kawarau bungee site, the drop is 43m. A particular jumper "weighs in" at 65kg.

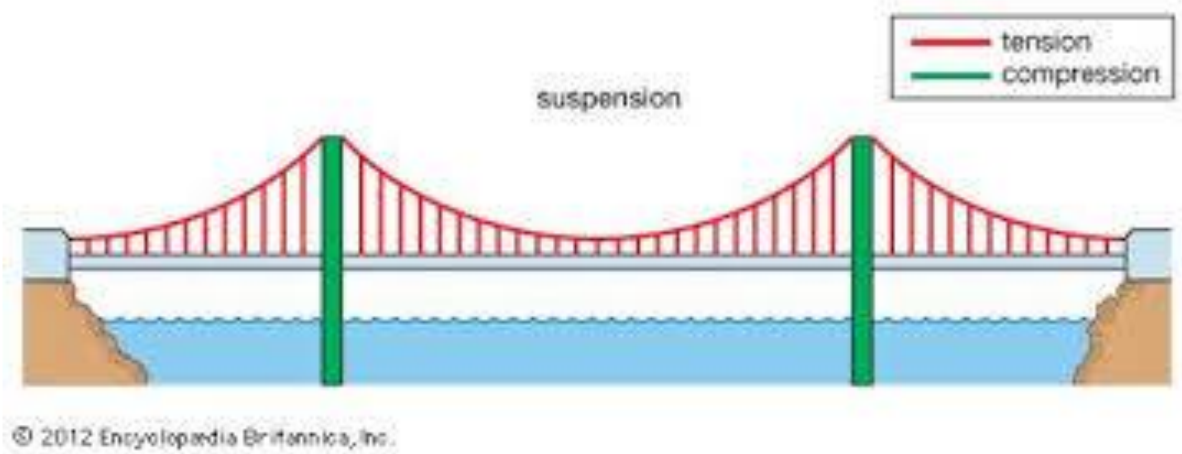
i) How much gravitational potential energy will they have at the top, standing on the bridge?
ii) If the un-stretched cord is 11m long, then how long will the cord need to stretch by to just dip the jumpers head in the river?
iii) Using your answers from i) and ii), calculate the spring constant of the cord used.

Part G Equilibrium

1. A father and son are playing on a see-saw. The son tells the father that if the father moves in toward the centre of the see-saw, they will be able to balance. The see-saw is 2.5m long, the son has a mass of 45kg and the father has a mass of 80kg.

i) Draw a diagram to show this situation.
ii) Explain what a torque is.
iii) Calculate the torque provided by the son. What direction is this torque?
iv) How far forward does the father have to move?
v) Explain why the son will move downwards if the father moves any further inwards than this.

2. A Suspension bridge is supported by two towers, as shown below. The length of the bridge is 700m, and it weighs 5MN. The towers are 150m in from the edges of the bridge.



i) On the diagram, label the distances from the right hand tower to the left hand tower, and from the right hand tower to the centre of mass of the bridge.
ii)With no traffic on the bridge, what is the force supplied from each tower?
iii) Calculate the support force supplied by the left hand tower when there is a 2000kg car 300m onto the bridge (from the left) and a 5000kg Truck 200m onto the bridge (from the left). Add to the diagram to help with this question.
iv) The maximum support that each tower can handle is 6MN; calculate the mass of the object that would need to drive onto the bridge to make it collapse.

Part H: Energy

1. Calculate the following:

i) The kinetic energy of a 50g tennis ball moving at $25ms^{-1}$

ii) The amount of gravitational potential energy of a 70kg diver at the top of a 10m board.

iii) The amount of energy stored in a spring with a spring constant of $16Nm^{-1}$ that has been stretched 11cm.

2. During a game of cricket, a batsman gets a top edge and the ball goes straight up in the air. The mass of a cricket ball is 140g. e ball was 1.5m off the ground when it was hit.

i) The ball goes 25m up in the air *from when it leaves the bat*. Calculate its gravitational potential energy at the top of its flight.
ii) Calculate how fast it was going at the moment it left the bat.
iii) The wicket-keeper catches the ball safely at a height of 0.5m off the ground. How fast was the ball going at this point?
iv) Ian Smith, who is commentating, thinks that this speed would have been the same even if the ball went to the boundary (but reached the same vertical height on the way). Mark Richardson argues with him, saying that he thinks the ball would be going fractionally slower. Discuss.

3. A 200g wooden block is dropped from a height of 1m onto s large spring. The spring compresses 0.1m.

i)Calculate the spring constant of the spring.
ii) Calculate how far the spring would compress if dropped from 6m.
iii) Assuming the block still lands perfectly on the spring even from 6m, explain why your calculation in ii) is not likely to be accurate.

Part I: Momentum and Impulse

1. Calculate:

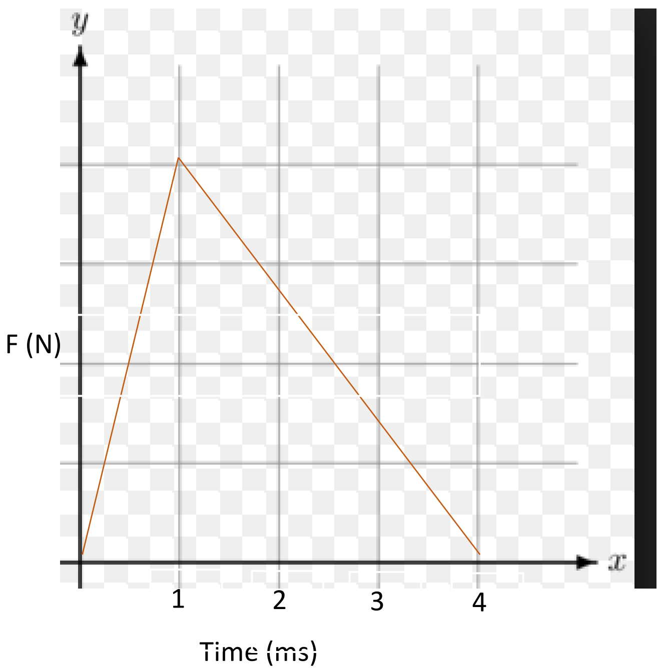
i) The momentum of a 60g egg thrown horizontally at a wall with a speed of $11ms^{-1}$.
ii) The speed that a 45g golf ball would have to be thrown at to achieve the same momentum

as the egg from i).

iii) Use impulse to explain why the golf ball would hurt more if you accidentally got in the way and it hit your face.

iv) When the golf ball from ii) bounces off the wall, it returns to the thrower horizontally again at a speed of $12ms^{-1}$. (The egg does not). Calculate the new momentum of the ball, and hence calculate the impulse of the collision with the wall.

The diagram below shows a Force-time graph for this collision:



v) Show that the peak of the graph is at 600N.

vi) Calculate the average force during this collision.

2. A 5kg bowling ball collides with a 1kg pin. The lane is very well oiled and there is no friction at all.

i) Explain why the ball travels at a constant speed down the lane (in terms of forces **and** momentum).

ii) If the velocity of the ball is $4ms^{-1}$ before the collision, and it slows to $2.4ms^{-1}$ after the collision, calculate the speed that the pin flies off at (assuming it flies directly backwards and not off on some angle).

iii) Explain why momentum is not conserved when the pin hits the back wall.