2

SUPERVISOR'S USE ONLY

91171

911710

NZQA

NEW ZEALAND QUALIFICATIONS AUTHORITY
MANA TOHU MĀTAURANGA O AOTEAROA

Level 2 Physics, 2014

91171 Demonstrate understanding of mechanics

2.00 pm Tuesday 18 November 2014
Credits: Six

Achievement	Achievement with Merit	Achievement with Excellence
Demonstrate understanding of mechanics.	Demonstrate in-depth understanding of mechanics.	Demonstrate comprehensive understanding of mechanics.

Check that the National Student Number (NSN) on your admission slip is the same as the number at the top of this page.

You should attempt ALL the questions in this booklet.

Make sure that you have Resource Sheet L2–PHYSR.

In your answers use clear numerical working, words and/or diagrams as required.

Numerical answers should be given with an appropriate SI unit.

If you need more space for any answer, use the page(s) provided at the back of this booklet and clearly number the question.

Check that this booklet has pages 2–11 in the correct order and that none of these pages is blank.

YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.

Merit

TOTAL 20

ASSESSOR'S USE ONLY

ASSESSOR'S USE ONLY

QUESTION ONE: BASKETBALL

Rachel is on her way to basketball practice. Her ball has a mass of 0.60 kg. m

(a) Rachel drops the ball from a balcony. It takes the ball 1.2 seconds to reach the ground. t

Calculate the size of the **impulse** on the ball during the time it takes to fall.

$\Delta P = F\Delta t$ $F = 0.6 \times 9.8 = 5.88$ N

$\Delta P = 5.88 \times 1.2 = 7.056 = 7.1$ Ns

N s

a

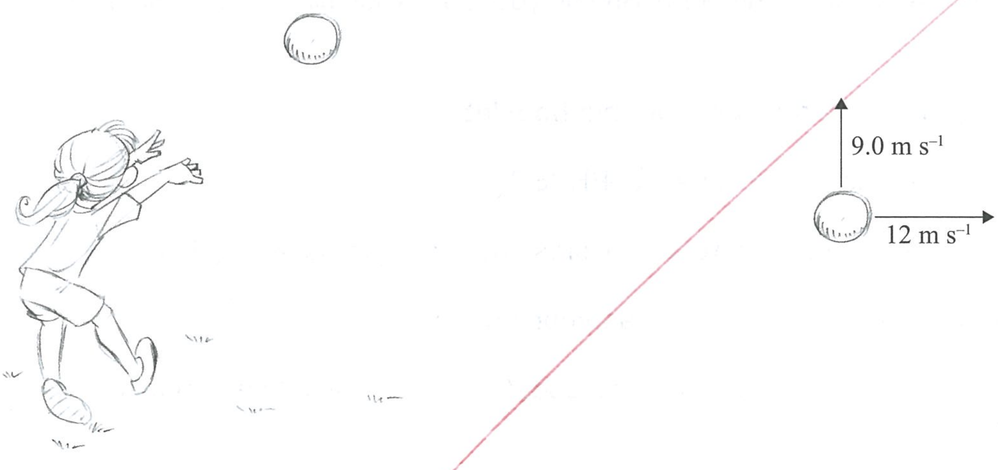
(b) Is the momentum of the **ball** conserved as it falls?

Explain your answer with reference to the conditions required for momentum conservation.

- Momentum is conserved because this is a collision between the ball and the ground.
- ~~the ground absorbs the ball's momentum, so~~ As the ball travels through the air, momentum is gained $p = mv$, v increases.

na

(c) Rachel throws the ball so it has a **vertical** component of velocity of 9.0 m s^{-1} and a **horizontal** component of velocity of 12 m s^{-1}, as shown in the diagram below.



State the size of the **vertical** component of velocity AND the **horizontal** component of velocity when the ball reaches the highest point.

Explain your answer.

You may ignore air resistance.

Vertical component = $0\ ms^{-1}$ 4

Explanation: The ball is at its highest point, so therefore it has no vertical velocity, no up or down movement ~~[illegible]~~, therefore its vertical velocity is $0\ ms^{-1}$

This is because the vertical velocity is effected by gravity, which decreases it as it rises, and increases it as the ball falls. 2

Horizontal component = $12\ ms^{-1}$ 4

Explanation: The horizontal velocity always remains the same when the ball moves in a projectile (Parabola. ). This is because the horizontal velocity is not effected by gravity. 2

M

(d) When the ball is compressed, it **acts** like a spring with a spring constant of 1200 N m^{-1}. k

When Rachel throws the ball at the wall, the ball compresses a distance of 9.0 mm. x 0.009 m

The ball has a mass of 0.60 kg. m

- Calculate the elastic potential energy stored in the ball when it is momentarily stationary against the wall.
- Calculate the maximum possible speed at which the ball rebounds.
- State any assumptions you make.

Elastic potential energy stored: $E_p = \frac{1}{2}kx^2 = 0.5 \times 1200 \times 0.009^2$

$= 0.0486 = \cancel{0.049}\ \boxed{0.0495}$

Maximum possible rebound speed: $E_p = E_k$

$E_k = \frac{1}{2}mv^2$

$E_k = 0.5 \times 60 \times v^2$

$0.049... = 30 \times v^2$

$v^2 = \frac{0.048...}{30}$

$\sqrt{v^2} = \sqrt{1.62 \times 10^{-3}}$

$v = 0.0402... = \boxed{0.040\ ms^{-1}}$

M

Assumptions made: That all energy was conserved. That none was lost to heat or sound on collision. ($E_p = E_k$). ~~So~~ 4

ASSESSOR'S USE ONLY

M5

ASSESSOR'S USE ONLY

QUESTION TWO: AT THE GYM

Jamie is doing a workout. He is using a barbell with weights on it. The total mass of the bar with the weights on it is 120 kg.

m

For copyright reasons, this image cannot be reproduced here.

http://www.makeoverfitness.com/images/stories/standing-barbell-tricep-extension.jpg

(a) Calculate the work done on the bar if Jamie lifts it 0.55 m vertically at constant speed.

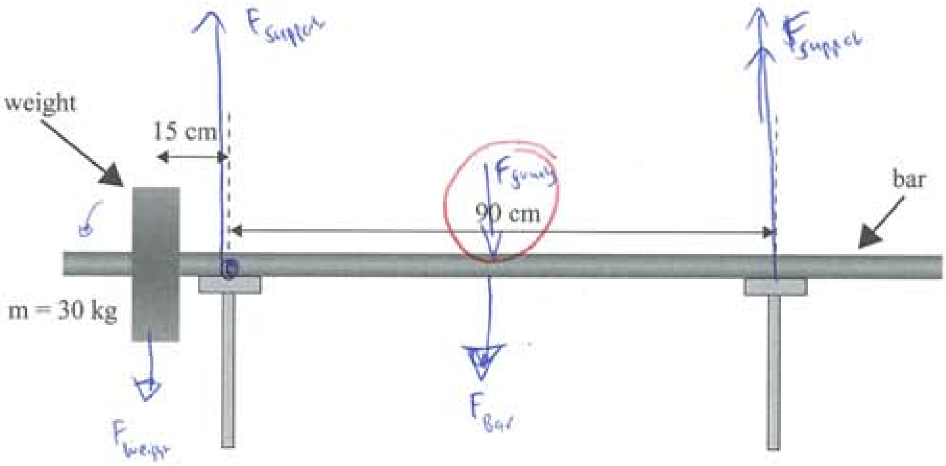
$W = Fd$

$W = (120 \times 9.8) \times 0.55 = \cancel{6246}\ 646.8 \therefore 647\,Nm$ | $647\,J$

a

(b) Jamie puts the barbell on two supports and changes the weights on the bar. With no weights on one end and a 30 kg weight on the other end, the support force provided by the right-hand support is zero.

- Draw labelled arrows on the diagram showing the forces on the bar.
- Use the concept of torque to calculate the weight of the bar. Assume it is a uniform bar.



If you need to redraw your labels, use the spare diagram on page 9.

na

Clockwise T = AntiClockwise T (Ac) | Clockwise T | $F = 73.5$

$T_{Ac} = T = F \times d$ | $T_c = F \times d$ | $m = \frac{F}{g}$

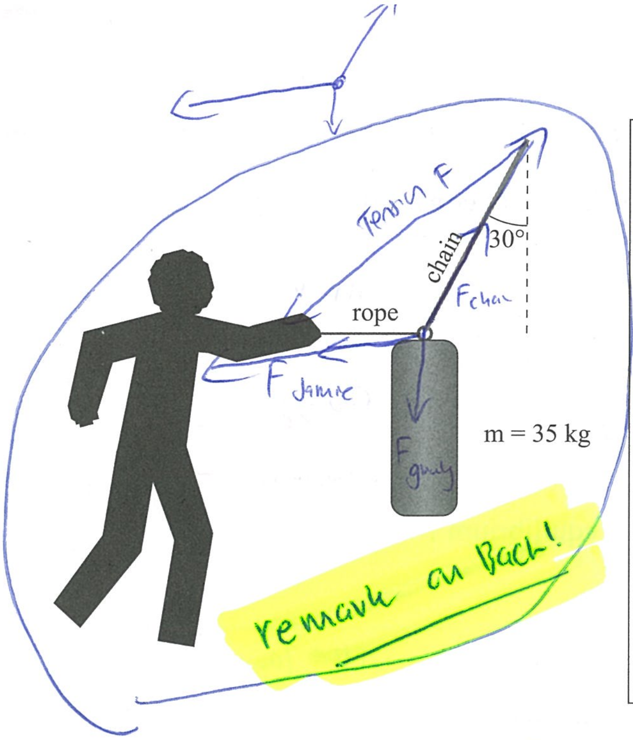
$T = (30 \times 9.8) \times 15 = 4410\,Nm$ | $4410 = F \times (45 + 15)$ | $m = \frac{73.5}{9.8}$

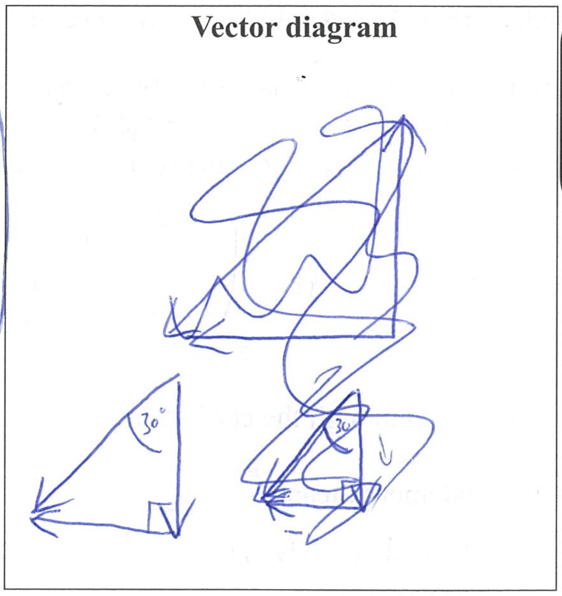
AntiClockwise T = Clockwise T | $F = \frac{4410}{60}$ $F = 73.5$ | $m = 7.5\,kg$

(c) After doing some weights, Jamie goes across to the punch-bag, which is a large bag hanging from a chain. The bag has a mass of 35 kg. Jamie pulls the bag horizontally, using the rope tied to a ring at the top of the bag, until the chain is at an angle of 30° to the vertical, as shown in the diagram opposite.

(i) Draw the three forces acting on the ring at the top of the bag.

(ii) By drawing a vector addition diagram of the three forces acting on the ring at the top of the bag, determine the size of the tension force on the chain.

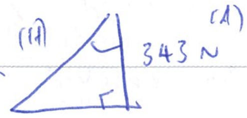




If you need to redraw your diagram, use the spare diagram on page 9.

ASSESSOR'S USE ONLY

(c) Downward: 35 × 9.8 = 343 N.



Tension Force = CAH

$\frac{343}{\cos 30} = F_T$

$T_T = 396.06..$

$\boxed{396\ N}$

M

(d) Jamie punches the bag horizontally. He then puts on a glove with thick padding and punches the bag again with the same velocity.

Discuss the difference between the two punches in terms of:

$\frac{1}{2}$ vs $\frac{1}{3}$

- the stopping time of his fist
- the force on the bag.

State any assumptions you make.

- Adding the gloving to his hand, will increase the stopping time of his fist, when he punches
- Since the stopping time is increased, and the velocity is the same, $a = \frac{v}{t}$ therefore the acceleration of his glove on impact will be less.

$F = ma$, therefore his Force felt will be less. But because of this, the force will transfer to the bag, therefore the bag will feel more force.

M

M5

ASSESSOR'S USE ONLY

QUESTION THREE: SHAMILLA DRIVES TO THE GYM

Shamilla and her car have a combined mass of 1100 kg. She is driving at **constant velocity**.

mass

(a) Calculate the size of the vertical force the road produces on the car.

m V

$F = ma$

$F = 1100 \times 9.8 = 10780$.

road produces a force of 10780 N on the car.

a

(b) Shamilla says that 'even though the car is moving, it is in equilibrium'.

Explain what this statement means.

- This means that it is traveling at a constant speed, all forces are balanced.
- It has reached terminal velocity.
- No net external forces acting on it

a

(c) A short time later, Shamilla's car accelerates from a speed of 2.0 m s^{-1} to a speed of 22.0 m s^{-1}, covering a distance of 72 m.

V_f V_i d

Calculate the size of the average net force on the car while it accelerates.

$V_f^2 = V_i^2 + 2ad$

$22^2 = 2^2 + 2a \times 72$.

$\frac{480}{72} = \frac{2a \times 72}{72}$

$\frac{2a}{2} = \frac{6.66...}{2}$ $a = 3.33...\ ms^{-2}$

$F = ma$

$F = 1100 \times 3.33...$

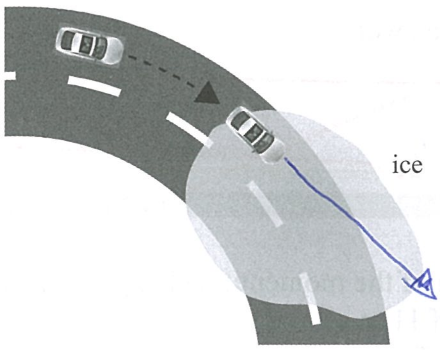
$= 3666.66...$

$\boxed{= 3667\ N}$

M

ASSESSOR'S USE ONLY

(d) Shamilla drives her car at constant speed around a corner, and then drives over some ice, as shown in the diagram below. You can assume there is no friction between the ice and the tyres.



- Describe the net force on the car (if any) before and after she reaches the ice.
- Explain how the net force (if any) affects the motion of the car before and after she reaches the ice.

~~When before she reaches the ice~~,

• As the car drives on the road, there is a friction force acting between the car tires, and the road.

• When the car hits the ice, there is no more friction, so this force or friction between the ~~tires~~ tires and the road is ~~gone~~ gone.

• Due to the loss of friction, the car will have less grip (friction is attraction, provides grip), the car will loose control. ∴ the car will most likely travel off the road, ~~at~~ in a ~~str~~ straight line (see diagram)

aa

A4

QUESTION FOUR: SHAMILLA DRIVES HOME

ASSESSOR'S USE ONLY

Shamilla and her car have a combined mass of 1100 kg.

(a) Calculate the total momentum of the car and Shamilla when the car has a velocity of 18 m s^{-1}.

Include the correct unit with your answer.

$p = mv$

$p = 1100 \times 18 = 19800\ \text{kgms}^{-1}$

a

(b) Calculate the size and the direction of the momentum change of the car as it slows from a velocity of 18 m s^{-1} to a velocity of 11 m s^{-1}.

$\Delta v = v_F - v_I = 11 - 18 = -7\ \text{ms}^{-1}$ | $p = mv$, $p = 1100 \times -7 = -7700\ \text{kgms}^{-1}$

M

(c) Shamilla puts her foot on the brake, and the car slows down.

Explain the principle of energy conservation in this situation, and identify the transfer of energy caused by braking.

- When she breaks, this causes her kinetic energy, to be transfered into heat and sound, through her ~~tires~~ tires to the ground (or breek pads).
- Energy Conservation ~~[illegible]~~ means no energy is lost, it is converted; In this case, from kinetic energy to heat/sound energy due to friction.

M

(d) Calculate the average rate at which the brakes transfer energy as the car slows from a velocity of 18 m s^{-1} to a velocity of 11 m s^{-1} in a time of 6.0 s.

v_I v_F t

~~$d = \frac{v_i + v_f}{}$~~

$v_f = v_i + at$

$11 = 18 + a \times 6$

$\frac{-7}{6} = a$

$\boxed{a = -1.166..\ \text{ms}^{-2}}$

$d = \frac{v_i + v_F}{2} t$

$d = \left(\frac{11+18}{2}\right) \times 6$

$\boxed{d = 87\text{m}}$

$F = ma$

$F = 1100 \times 1.166..$

$= 1283.333..$

$W = Fd$

$W = 1283.3.. \times 87$

$= 111650\ \text{J}$ given out (lost).

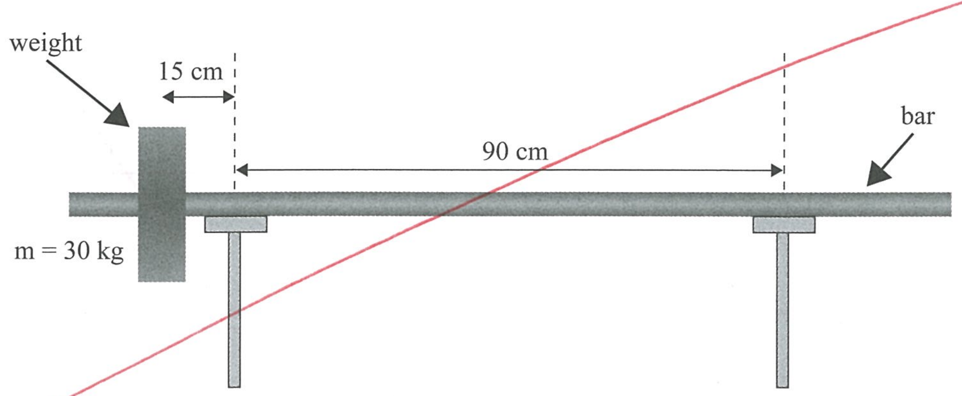
M

M6

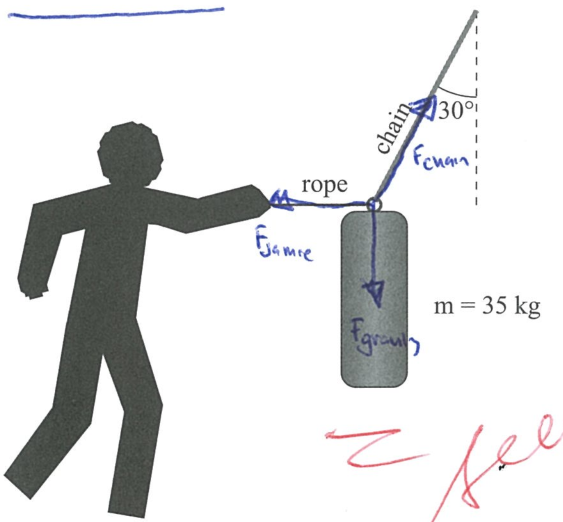
If you need to redraw your diagrams from Question Two, draw them below. Make sure it is clear which diagram you want marked.

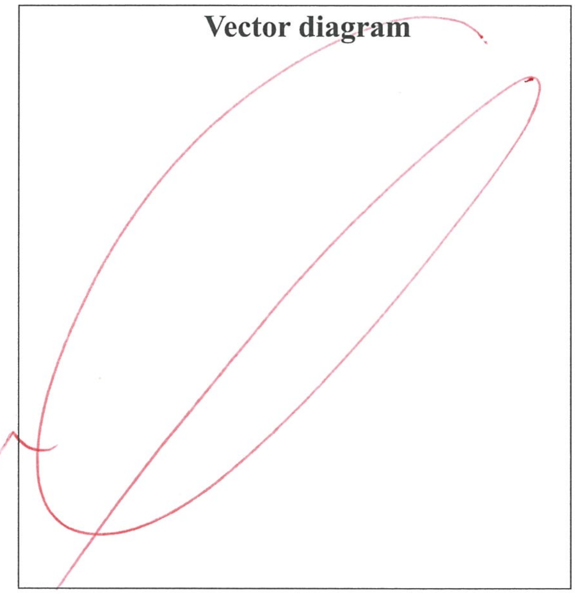
ASSESSOR'S USE ONLY

(b)



(c) Redrawn





Merit exemplar for 91171 2014		Total score	20
Q	**Grade score**	**Annotation**	
1	M5	The candidate provides sufficient evidence for M5 in this response, as, apart from an error in converting units, the numerical solutions are competently done. The explanation for the sizes of the vertical and horizontal components of projectile motion is well expressed. The response to the question on conservation of momentum suggests that the candidate does not understand the meaning of conservation as applied to momentum.	
2	M5	This response shows adequate evidence for M5. Two of the three calculations are performed correctly; the third shows a careless error. A force diagram includes an extraneous force. The discussion of the effects of not using/using a glove on a punch bag demonstrates in-depth understanding of the physics ideas relating force to acceleration, but is incomplete in not including an assumption.	
3	A4	This response does not reach the Merit level. Although the calculations are proficient, neither the explanation of equilibrium nor the discussion of the forces involved in driving a car around an icy corner show any more than a basic understanding of the physics relating to these contexts.	
4	M6	This response provides clear evidence for Merit. The explanation of conservation of energy is well applied in the context of the question, and the numerical problems are answered competently, with the exception of the final stage in finding the power of the brakes. Had that last step been completed, the candidate would have gained E8 for this question.	