91171

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SUPERVISOR'S USE ONLY

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.

Achievement

TOTAL 14

ASSESSOR'S USE ONLY

QUESTION ONE: BASKETBALL

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

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

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

$\frac{\Delta p}{F \mid \Delta t}$

~~F~~ $\Delta p = $ ~~F×Δt~~ $\qquad 0.60 \times 9.8\ \text{ms}^{-2}$

~~F=m×a~~ $\qquad F = 5{,}886\ \text{N}.$

Δt

$\Delta p = F \times \Delta t \qquad 5.886\text{N} \times 1.2 = 7.1\ \text{kgms}^{-1}$

a

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

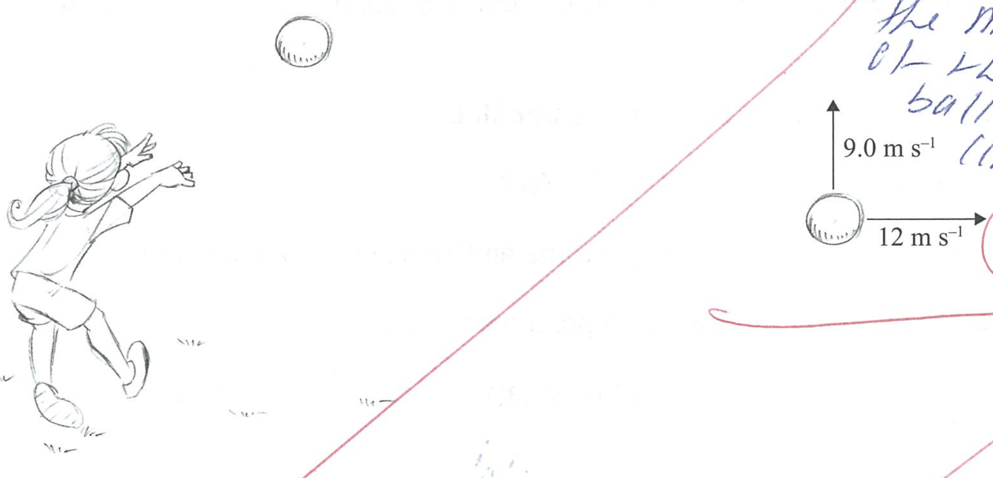
Explain your answer with reference to the conditions required for momentum conservation.

The Conservation of momentum suggests that momentum is conceived if there is a constant acceleration and force acting on the ball with no external forces. This is because as stated in Newtons ~~first~~ law of motion an object is moving at a constant speed or is stationary until an external resultant force acts on it. Therefore the momentum of the ball is conserved

$p_i = p_f$

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 = Zero

Explanation: This is because as the ball accelerates upwards with a force of $-9.8ms^{-2}$ it will then reach 0 at its highest point and begin to decelerate at a rate of $9.81ms^{-}$. Therefore at its highest point the vertical *

Horizontal component = $12ms^{-1}$ to the right

Explanation: the horizontal component is constant because there are no resultant external forces acting on it. This is because there is no air resistance.

M

* Component is zero in a downwards direction.

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

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

The ball has a mass of 0.60 kg.

- 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: $E_p = \frac{1}{2} \times k \times x^2$. $\frac{1}{2} \times 1200 Nm^{-1} \times 9.0mm$

$= 609$ Joules. $= 610 J$

Maximum possible rebound speed:

na

Assumptions made: There is no external forces acting on the ball. eg drag, air resistance / friction.

A3

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.

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=F×d   F=m×a.

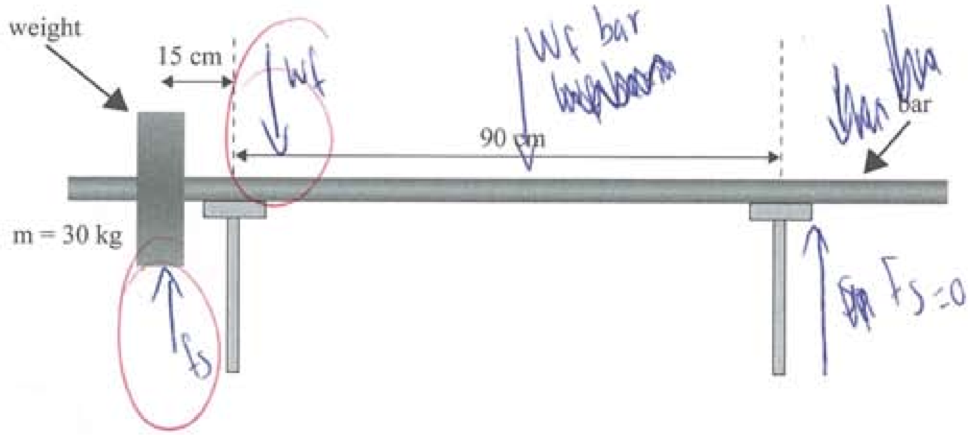
W=?×0.55   120×9.81=1177.2N

W=1177.2N×0.55m =647.46J = 647J

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.

$T_c = T_{ac}$ (Torque clockwise = torque anti clockwise)

W = F×d.   T=F×d.

W=F

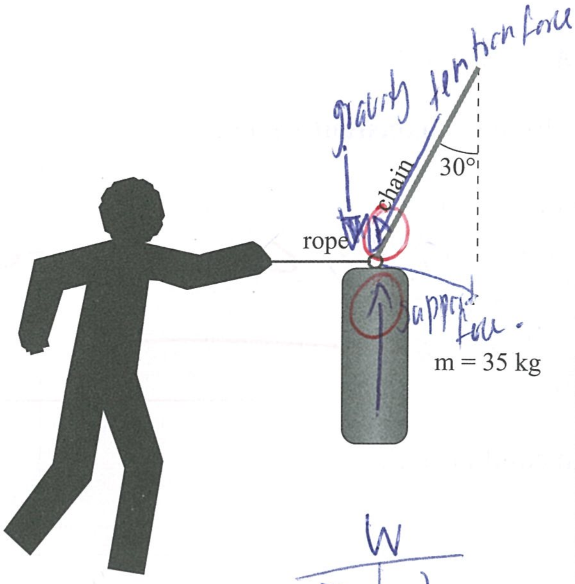
=(30×9.81×46.5) 13684.45J close at work.

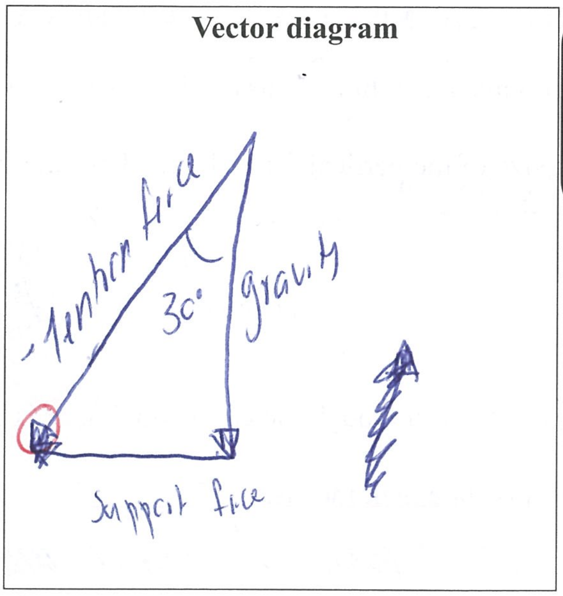
na

(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

$$\frac{W}{F \mid d}$$

SOH CAH TOA.

$F = \frac{W}{d} \times \sin 30$

na

(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:

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

State any assumptions you make.

When Jamie punches the bag without a glove on his punch has the same momentum as it would with the glove on because ~~they~~ momentum ~~p~~ is conserved ($p_i = p_f$). This means that the momentum is unaffected but the force is not. ~~Thus~~ $\Delta p = F\Delta t$. By Jamie wearing gloves he is increasing the stopping time and because of the equation $\Delta p = F\Delta t$ this means that there is a smaller force acting back from the bag to his fist. Meaning Jamie is ~~unable~~ to feel the forces pushing back on his hand less with gloves on.

M

A3

QUESTION THREE: SHAMILLA DRIVES TO THE GYM

ASSESSOR'S USE ONLY

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

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

1100kg × 9.81 = 10791N

Mass × a = F

a

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

Explain what this statement means.

Equilibrium is when the linear and rotational componants are equal/stationary. This means that the sum of the torques and the sum of the net forces and both sum to zero. Therefore equalibrium is achieved if she is moving at a constant speed

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.

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

$\Delta v = 20 ms^{-1}$

$V_i = 2.0 ms^{-1}$

$V_f = 22.0 ms^{-1}$

distance = 72.

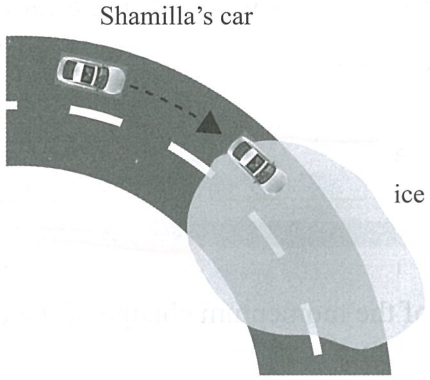
4.905

-72

na

ASSESSOR'S USE ONLY

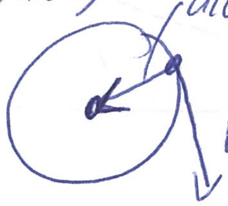
(d) Shamilla drives her car at constant speed around a corner, and then drives over some ice, as shown in the diagram below. You can assume there is no friction between the ice and the tyres.



Circular motion.

- 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 traveling in a circle there is a force acting towards the center called the centripetal acceleration. $a_c = \frac{v^2}{r}$. This is created through the friction that the tires have with the road. Because when she is on ice some of this friction will be lost her car could skid (breaking the circular motion) but once the friction is regained the car will carry on in the circular motion with the same centripetal acceleration as before the ice because there is no friction force between the ice & the ~~tyres~~ tyres. The net force (centripetal acceleration) accelerates the car towards the middle of the circle. All though the velocity (when no horizontal



componants are acting means that the car would travel in a straight line (tangent to the circle).

M

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=m×V
p = 1100 × 18ms⁻¹ = 19800 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}.

Pi = 19800
pf = 1100×11ms⁻¹ = 12100

Δp = 7700 in the same direction
~~[illegible]~~
by the friction of

a

(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.

Energy can not be destroyed or created only transferred. In this case Shamilla had kinetic energy, once her foot goes on the break the car began to decelerate, this means that (Spare paper)

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.

Ek = ½ × m × V².
Ek = ½ × 1100 × 11ms⁻¹ = 605

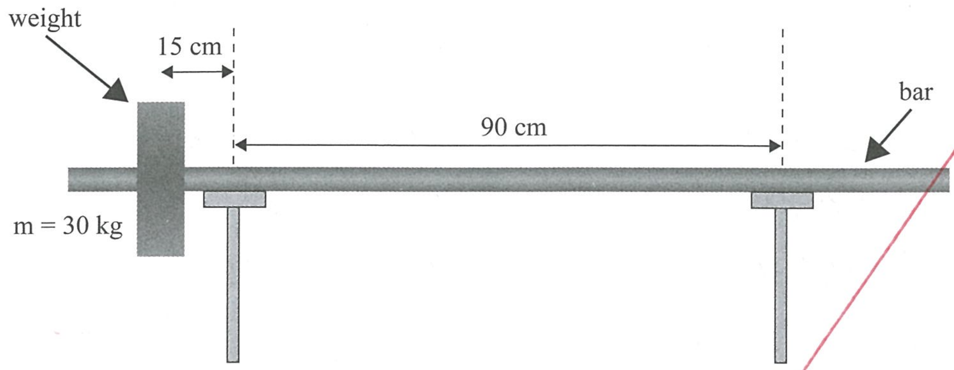
605 J / 6.0 s = 100.

na

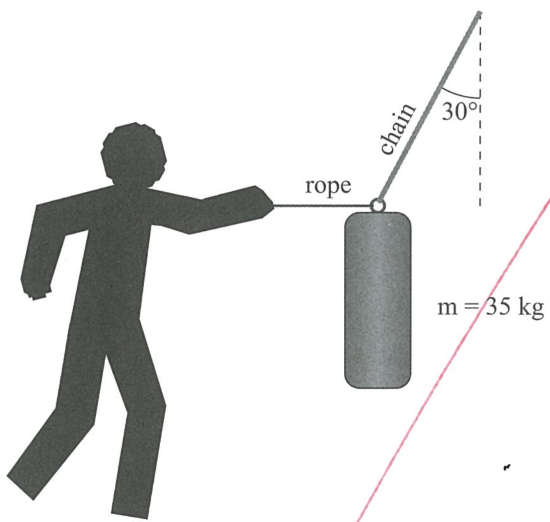
A4

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

(b)



(c)



Vector diagram

Extra paper if required.
Write the question number(s) if applicable.

QUESTION NUMBER

ASSESSOR'S USE ONLY

Q4 c. There was more friction being created between the tyres and the road. This friction creates heat energy & sound energy. Also as the car ~~decreases~~ decelerates to a stop the kinetic energy is being transfered into ~~grav~~ potential energy

Seen

Achievement exemplar for 91171 2014		Total score	14
Q	**Grade score**	**Annotation**	
1	A3	This candidate shows adequate evidence for Achievement. The solution to the single-step numerical problem displays clear basic understanding, and the explanation for the sizes of the vertical and horizontal components of projectile motion is well expressed. However, in the discussion of conservation of momentum there is no clear understanding while the multi-step calculation proves too challenging.	
2	A3	This response is evidence for Achievement. The candidate can perform a single-step calculation but is unable to draw free body force diagrams correctly. The more involved problems are too demanding, but there is a good discussion of the effects of not using/using a glove on a punch bag. Had this explanation included the fact that the change of momentum was the same in both cases (rather than just the momentum), it would have been A4 rather than A3.	
3	A4	This response shows clear evidence for Achievement. The candidate carries out a single-step calculation that requires correct understanding and makes one of two relevant points when explaining the meaning of equilibrium. The multi-step problem that a Merit candidate would be expected to solve proves too complex. An explanation of the forces involved in driving a car around an icy corner shows some understanding but displays inconsistencies and is incomplete.	
4	A4	The candidate provides sufficient evidence for Achievement in this question. Two calculations are done accurately, and the explanation of the concept of conservation of energy is clearly described in the given context. The final multi-step numerical problem is too challenging.	