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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.

Excellence

TOTAL 28

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QUESTION ONE: BASKETBALL

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.

$\Delta p = F\Delta t$

$= 7.056 \text{ kgms}^{-1}$

a

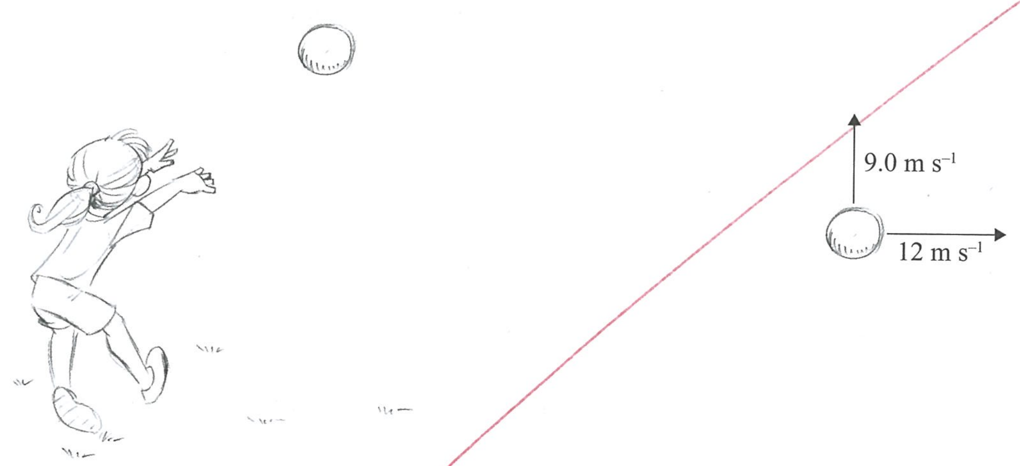
(b) Is the momentum of the **ball** conserved as it falls?

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

Momentum is ~~conse~~ defined by the equation p=mv. Since velocity is changing due to the force of gravity, the momentum is changing and therefore not conserved as there is an external force acting

M

(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.

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Explain your answer.

You may ignore air resistance.

Vertical component = $0 ms^{-1}$ a

Explanation: On the way up, the ball is experiencing deceleration as it is moving against the force of gravity and so the net force acting downwards will slow the ball down to $0 ms^{-1}$ vertically at the top before it starts to accelerate downwards.

Horizontal component = $12 ms^{-1}$ a

Explanation: There are no forces acting on the ball in the horizontal direction so therefore there is no acceleration and throughout the journey the ball will have a constant horizontal velocity of $12 ms^{-1}$ a

M

(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: $E_p = \frac{1}{2}kx^2$ $\quad 0.049 J$

$\frac{1}{2}(1200) \times 0.009^2 = 0.0486 J$

Maximum possible rebound speed: $E_K = \frac{1}{2}mv^2$

$\frac{1}{2} \times 0.6 \times v^2 = 0.0486$

$0.402 ms^{-1}$ $\quad 0.40 ms^{-1}$ a

Assumptions made: All E_p was converted to E_K - none lost to surroundings a

e

E8

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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.

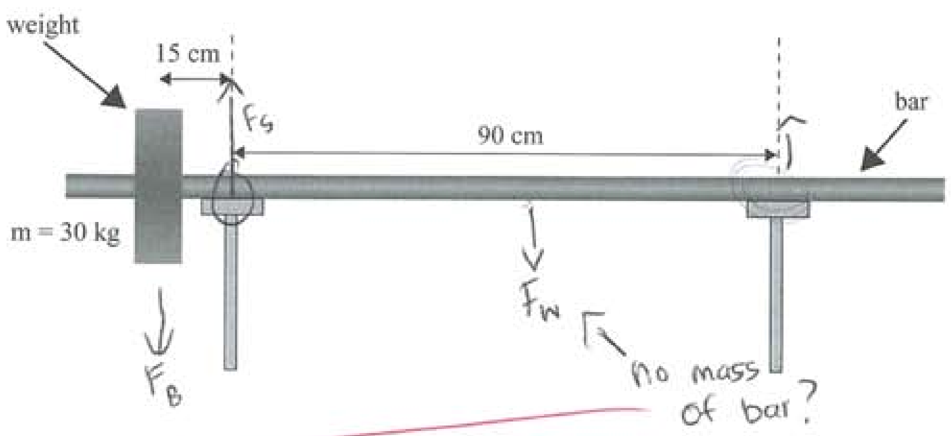
$W = Fd$

$= 120 \times 9.8 \times 0.55 = 646.8 \quad 650\,J$ ✓

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.

$T_c = T_{ac}$ ~~$F_W \times d_W + F_B d_B = F_S d_S$~~

~~$30 \times 9.8 \times 1.05 = F_S \times 0.9$~~

~~$= 343\,Nm$~~ $0.45 \times F_W = 294 \times 0.15$

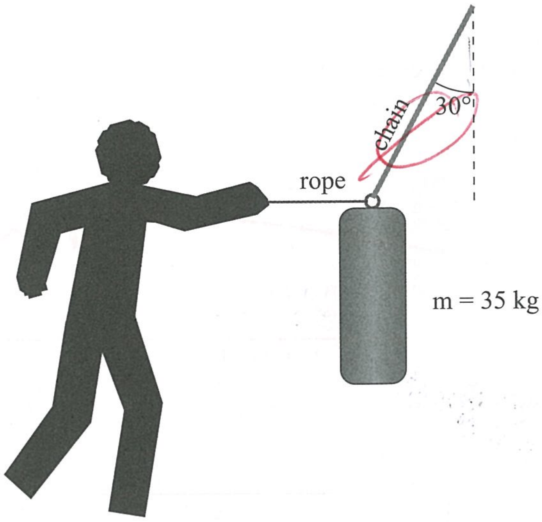
$F_W = 98 \div 9.8 = 10\,kg$

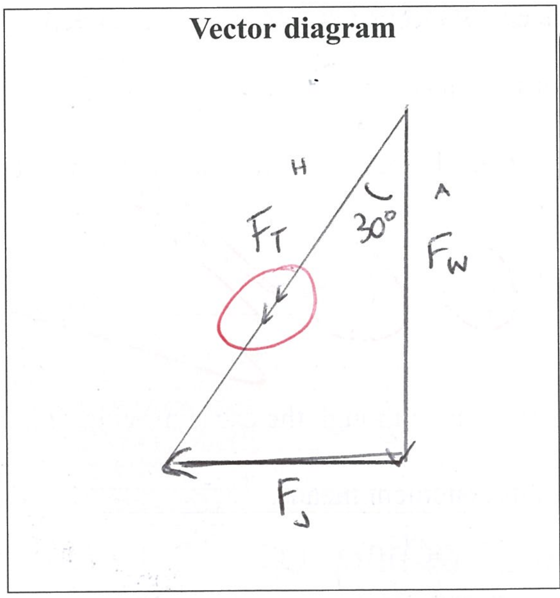
m

(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.

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$\cancel{F_{fa}}$ $F_W = 35 \times 9.8$

$= 343N$

$F_T = \cancel{34} \; 343 \div \cos 30$

$= 396N$ ✓

a

(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.

The physics principle discussed is $\Delta p = F\Delta t$. If Jamie put gloves on, this means that with the same change in momentum as his velocity stays the same, the time of the collision will increase as the padding will mean that the time of impact is longer. If he did not have padding, the time of impact would be shorter. Therefore, with an ~~decrease~~ increase in Δt with the same ~~mo~~ Δp, the force will be smaller on Jamies hands and therefore the bag so with padding, the bag would not travel as far of a distance horizontally as it would without padding

e

E7

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.

F = ma
= 1100 × 0 = 0N

na

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

Explain what this statement means.

The forces acting up on the car and down on the car are equal, torque clockwise = torque anticlockwise.

na

(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.

$v_f^2 = v_i^2 + 2ad$

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

$484 = 4 + 144a$ $\quad 480 = 144a$

$a = 3.33 ms^{-1}$

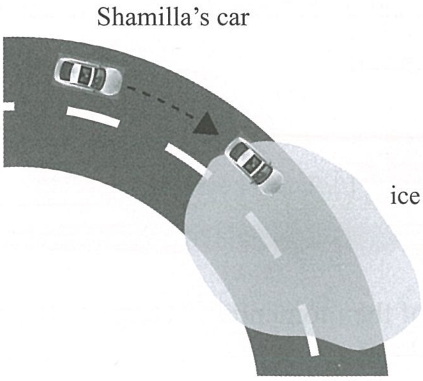
$F = ma$

$= 3.33 \times 1100 = 3666.7 \quad 3700N$

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 she is driving around the corner, she is in centripetal motion. When an object is in centripetal motion, a force acting towards the centre is required as th car is constantly changing velocity (a vector) and this requires a force to accelerate. The centripetal force keeping th car in centripetal motion is friction between the tyres and the road. When th car reaches the ice patch, this centripetal force is removed as ture is no friction, and since the car is moving at a constant speed, and th only force acting on it has been removed, it will move off on a straight line tangent with constant velocity as there are no forces present to change th velocity, so its ~~speed~~ ~~velocit~~ speed and direction will stay th same after she reaches the ice.

e

M5

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.

$p = mv$

$= 1100 \times 18 \quad = 19800 \text{kgms}^{-1} \quad$ ~~19~~ 20000 kgms^{-1} ✓

Q

(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}.

$\Delta p = p_f - p_i \quad p_f = 12100 \text{ kgms}^{-1}$

$12100 - 19800 \quad = 7700 \text{kgms}^{-1}$ in the opposite direction to ~~direction~~ of travel ✓

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.

Energy is not created or destroyed, but transformed into other forms. When Shamilla puts her foot on the break, there is now a net force (friction) acting in the opposite direction to the car's motion, so it loses kinetic energy. This kinetic energy is transformed into forms such as heat energy between tyres and road, and sound energy. ✓

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.

$V_f = V_i + at$

$18 = 11 \times 6a$

$a = 1.167 \text{ ms}^{-2}$

$d = \left(\frac{V_i + V_f}{2}\right)t$

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

$= 87\text{m}$

$F = ma$

$= 1100 \times 1.167$

1283 N

$W = Fd$

$1283 \times 87 \quad = 111650 \text{ J}$

$P = \frac{W}{t}$

$= \frac{111650}{6}$

$= 18608.3$

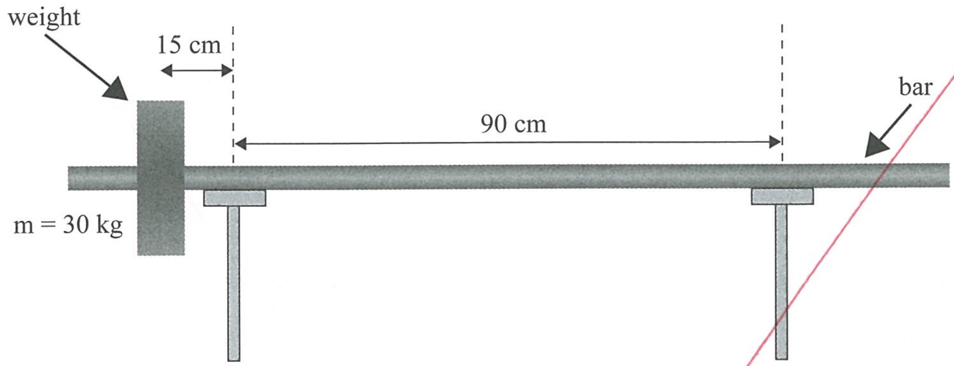
19000 W ✓

e

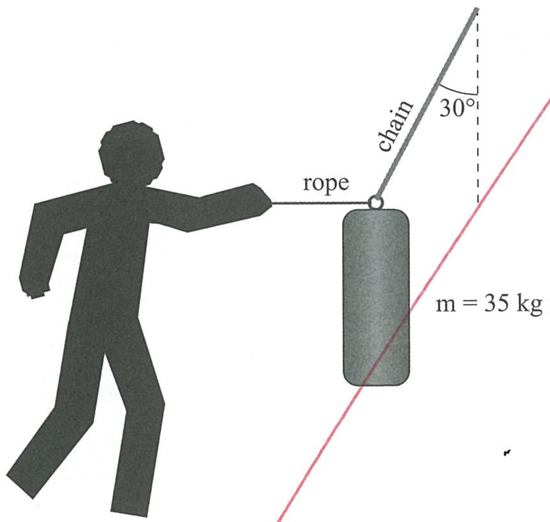
E8

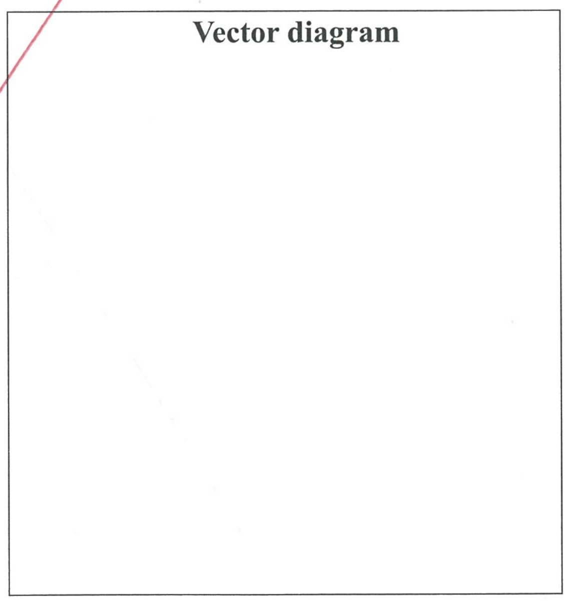
If you need to redraw your diagrams from Question Two, draw them below. Make sure it is clear which diagram you want marked.

(b)



(c)





Excellence exemplar for 91171 2014			Total score	28
Q	**Grade score**	**Annotation**		
1	E8	This response provides clear evidence for Excellence. Both of the numerical solutions are presented accurately. The explanation based on the principle of conservation of momentum shows that the candidate is able to apply their knowledge to the given, slightly unusual context. The reasons for the sizes of the vertical and horizontal components of projectile motion are clearly and fully expressed.		
2	E7	Sufficient evidence is provided for E7 in this response. The candidate solves the numerical problems economically and accurately. The discussion of the effects of not using/using a glove on a punch bag demonstrates comprehensive understanding of the physics concept of impulse. Had the candidate shown the direction of the tension in the chain instead of the direction of the resultant of the weight force and the rope tension, they would have gained E8.		
3	M5	Surprisingly, the candidate does not recognise that the vertical support force of the road on the car is equal to the weight of the car. The explanation of equilibrium is incomplete and does not include the necessary condition of zero net force, nor does it state the resulting zero acceleration. The second calculation is competently performed, and the discussion of the forces involved in driving a car around an icy corner shows comprehensive understanding of principles, written in the candidate's own words.		
4	E8	This response affords strong evidence for Excellence. All numerical solutions are carried out competently, with the many steps used to reach the final answer for power showing comprehensive understanding of several principles. The application of the concept of conservation of energy is clearly described in the given context.		