2

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91171

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# Level 2 Physics, 2015

## 91171 Demonstrate understanding of mechanics

9.30 a.m. Tuesday 17 November 2015
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 2–12 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: PROJECTILES**

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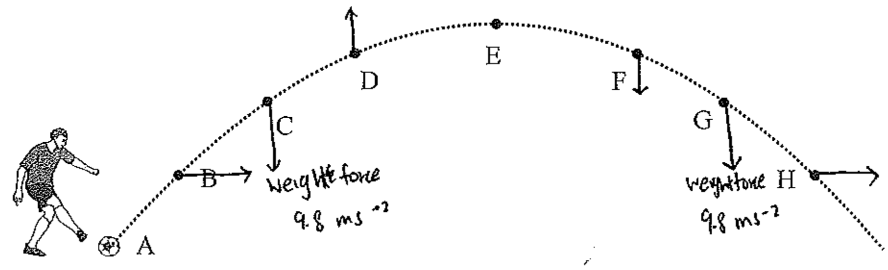
Roy kicks a ball. The diagram below shows the trajectory of the ball. You may assume air resistance to be negligible.



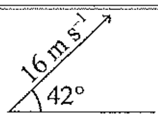

*If you need to redraw your labelled arrows, use the spare diagram on page 10.*

M

(a) On the diagram draw **labelled arrows** of **appropriate length** to show the following:

- the force on the ball at position C and at position G
- the horizontal component of the velocity of the ball at position B and at position H
- the vertical component of the velocity of the ball at position D and at position F.

(b) The ball is kicked with an initial velocity of 16 m s$^{-1}$, at an angle of 42° to the ground.




Calculate the initial horizontal and vertical components of the velocity of the ball at position A.

Horizontal velocity: $\cos 42 = \frac{V_H}{16}$   Vertical velocity: $\sin 42 = \frac{V_V}{16}$

$V_H = 11.9 \text{ m s}^{-1}$   $V_V = 10.7 \text{ m s}^{-1}$

a

(c) State the horizontal and vertical components of the velocity of the ball at position E.

Explain your answers.

The horizontal velocity of the ball at position E is 11.9 ~~as the~~ m s$^{-1}$, as there is no unbalanced external force acting on the ball horizontally throughout, so the horizontal velocity is constant.

The vertical velocity of the ball is 0 m s$^{-1}$, as there is a gravitational force 9.8 m s$^{-2}$ acting downward on the ball constantly throughout. At position E, the gravitational force that is acting downward had cancel out the initial vertical velocity that ~~going~~ acting upwards which is 10.7 m s$^{-1}$. Therefore the vertical velocity of the ball is 0 m s$^{-1}$ at position E.

M

(d) Calculate the horizontal distance the ball travels before returning to the level from which it was kicked.

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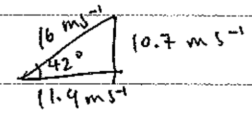


$v_f = v_i + at$

$0 = 10.7\ t - 9.8\ t$

$t = 1.09\ s$

$t = 1.09 \times 2 = 2.18\ s$

$v = \frac{\Delta d}{\Delta t}$

$11.9 = \frac{\Delta d}{2.18}$

$\Delta d = 25.942\ m$

$\Delta d = 26m$ → reach the ground

horizontal distance before returning is less than 26m.

E.g. At point H : $V_f = V_i + at$

$-8.025 = 10.7\ t - 9.8t$

$t = 1.91\ s$

$V = \frac{\Delta d}{\Delta t}$

$11.9 = \frac{\Delta d}{1.91}$

$\Delta d = 22.74m$

$d = 23m.$

e

E8

## QUESTION TWO: ICE SKATING

Janet and Roy are ice skating.

(a) At one point, Roy is standing still, and Janet glides up to him from behind and grabs him by the shoulders. Janet's velocity as she glides up to Roy is 5.0 m s$^{-1}$, and together they glide off at a velocity of 2.2 m s$^{-1}$ in the same direction as Janet was gliding (assume that both Janet's and Roy's skates are pointing in the direction of travel). Roy has a mass of 65 kg.

http://sport-kid.net/ice-skating-fall-couple.html

(i) State the law of physics that applies to this situation.

~~conservation of monmentum~~ conservation of momentum

(ii) Calculate Janet's mass.

$P_i = P_f$

$mv = mv$

$m \times 5 = (65 + m) \times 2.2$

$m = 0.44 (65 + m)$

$m = 28.6 + 0.44m$

$0.56m = 28.6$

$m = 51.1 \text{ kg} = 51 \text{ kg}$

(iii) Explain why you can use the assumptions you made when calculating Janet's mass.

The change of momentum is conserved, as the initial momentum of Janet & Roy is ~~equal~~ conserved to the final momentum of Janet and Roy together, assuming that no external forces are applied. This can be applied when the initial momentum is the same as the final momentum.

a

m

a

After removing her skates, Janet jumps down to the ground from a high bench.

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(b) Write a comprehensive explanation of what Janet needs to do while landing, so that she does not hurt herself.

Use a formula to explain your answer.

In order to not hurt herself, the force acts on her while Janet lands needs to be small. This force can be reduced by increasing the time impact. Since $\Delta p = F\Delta t$, assumes that $\Delta p$ is the same and when t increases, F will decrease. Janet can bend while landing, which will create a greater surface area of her body to ~~contact with~~ increase the air resistance which is acting upwards on her, this will decrease the net ~~the ground as she lands. this will increase the time of impac~~ ~~of impact for her~~ force that is acting downward and hence it will ~~decrease~~ increase ~~to land. Therefore the increase in time effectively~~ the time of impact as she lands. Therefore the increase in time effectively reduces the forces acting on Janet as she lands and hence the forces decreases and ~~she does~~ she will not hurt herself.

e

(c) When Janet jumps down, is her momentum conserved?

Explain.

No, because conservation of momentum only applied to a close system ~~here~~ it does ~~not~~ has any external forces acting on her. However, when Janet jumps down, there is 2 external forces acting on her which are weight force acting downwards and air resistance acting upwards. these 2 forces are not balanced, therefore the momentum is not conserved due to the presence of external forces.

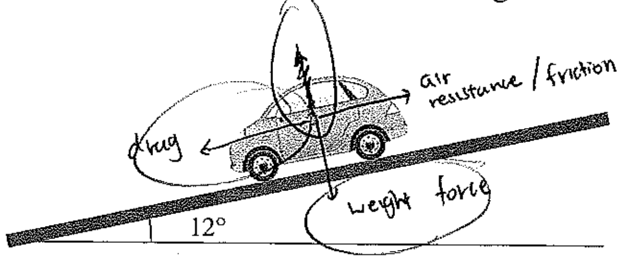
a

E8

## QUESTION THREE: JANET'S CAR AND SPRINGS

Janet arrives home. She parks the car on a slope that is at 12° to the horizontal, as shown in the diagram below.

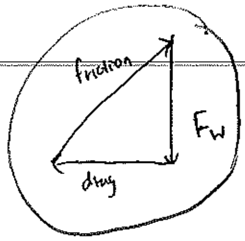
(a) Draw **labelled arrows** to show the **individual forces** acting on the car.




*If you need to redraw your labelled arrows, use the spare diagram on page 10.*

(b) Explain in terms of forces acting on the car, how the car remains stationary on the slope.

You may draw a vector diagram to help your explanation.

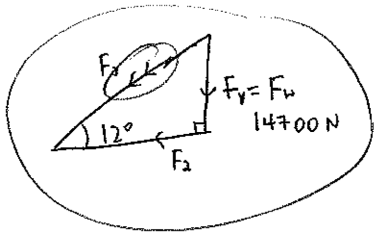



~~The f~~ For the car to remain constant, the 3 forces that acting on the car must be balanced, in order ~~to~~ for it to be balanced and have no net forces acting on the car, a close triangle needs to be created from the 3 forces//

(c) The mass of the car is 1500 kg.

Carry out calculations to show how forces keep the car stationary while it is parked on the slope.

You may draw a vector diagram to help your calculation.




$F_1 = F_w$ $F_2$ : $\tan 12° = \frac{14700}{F_2}$

$F_w = mg$ $F_2 = 3124.6$ N

$F_w = 1500 \times 9.8$ $F_2 = 3125$ N

$F_w = 14700$ N

$F_3^2 = 14700^2 + 3125^2$

$F_3 = 15028$ N

a

(d) The sofa in Janet and Roy's house has springs. When Roy sits on the sofa, the springs compress by 0.075 m.

Calculate the elastic potential energy stored in the springs. (Roy has a mass of 65 kg.)

$E_p = \frac{1}{2} k x^2$ $F = -kx$

$E_p = \frac{1}{2} \times 8493.3 \times 0.075^2$ $65 \times 9.8 = -k \times 0.075$

$E_p = 23.9$ J $k = 8493.3$ N m$^{-1}$

$E_p = 24$ J.

M

A4

## QUESTION FOUR: CIRCULAR MOTION AND TORQUES

(a) Janet swings a ball tied on a string in a horizontal circle above her head.

Explain why the ball is accelerating even though it is swinging at constant speed.

http://www.shutterstock.com

Since the ball is travelling in a circular path/motion, which means that even though the ball is swinging at constant speed, but it constantly changing direction. Velocity is a vector, so changing in direction results in a change in velocity. The rate of change in velocity is acceleration. Therefore the ball is accelerating since the ball is keep changing its velocity.

(b) The length of the string is 0.75 m. It takes 0.84 seconds for the ball to go around her head once.

Calculate the acceleration of the ball.

$a_c = \frac{v^2}{r}$ $\qquad v = \frac{\Delta d}{\Delta t}$

$a_c = \frac{5.61^2}{0.75}$ $\qquad v = \frac{2\pi r}{\Delta t}$

$a_c = 41.96\ ms^{-2}$ $\qquad v = \frac{2\pi \times 0.75}{0.84}$

$a_c = \cancel{41.9}\ 42\ ms^{-2}$ $\qquad v = 5.61\ ms^{-1}$

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(c) Name the force that causes the ball to accelerate as it goes in a circle.

Explain why the force causes the ball to accelerate.

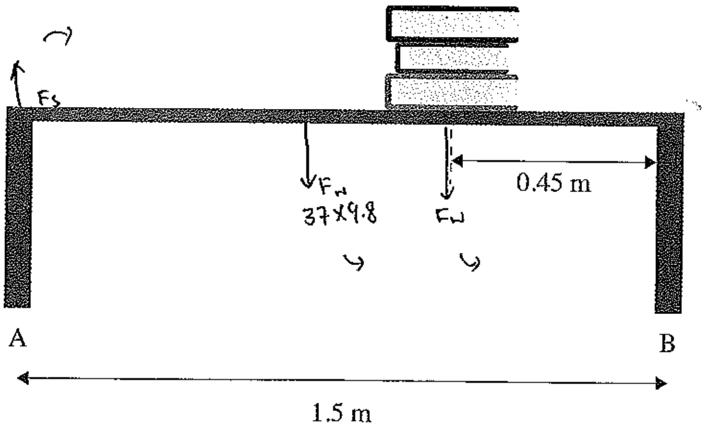
The force that causes the ball to accelerate is tension create between the ~~keep~~ string & Janet. This tension force acts at 90°, ⊥ to the velocity of the ball. Since acceleration requires a ~~force~~ net force, and it is this force that keep the ball travelling in a circulation motion and hence it keep changing its velocity and accelerates. Without this force, the ball would travel in a straigh line that is tangential to the direction that the ball was travelling (circular motion) at a constant speed. //

m

(d) Janet's study table has two panels, one at each end. Janet has a pile of books on her table.

Use the details given below to calculate the support force provided by panel A of the study table.

Mass of table = 37 kg
Length of table = 1.5 m
Mass of books = 7.4 kg
The weight of the books acts at a distance of 0.45 m from end B of the table.
Assume Janet's study table is uniform.




Take B as a pivot: $\tau_{cw} = \tau_{acw}$

$F_s \times 1.5 = 37 \times 9.8 \times 0.75 + 7.4 \times 9.8 \times 0.45$

$1.5 F_s = 304.584$

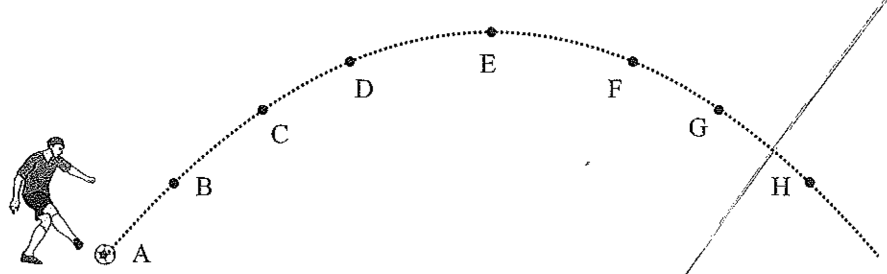
$F_s = 203.1 \text{ N} = 203 \text{ N}$ //

e

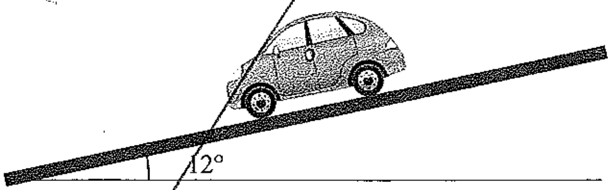
E8

## SPARE DIAGRAMS

If you need to redraw your labelled arrows on the diagram from Question One (a), draw them on the diagram below. Make sure it is clear which diagram you want marked.




If you need to redraw your labelled arrows on the diagram from Question Three (a), draw them on the diagram below. Make sure it is clear which diagram you want marked.



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

QUESTION NUMBER

ASSESSOR'S USE ONLY

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## Annotated Exemplars 2015

| **Excellence exemplar for 91171 2015** | | **Total score** | **28** |
|---|---|---|---|
| **Q** | **Grade score** | **Annotation** | |
| 1 | E8 | This response provides clear evidence for Excellence. The candidate takes care to draw arrows of appropriate lengths on the diagram of the projectile trajectory. Horizontal and vertical velocities are clearly differentiated. The reasons for the sizes of the vertical and horizontal components of projectile motion are clearly and fully expressed. The numerical solution is presented accurately and succinctly | |
| 2 | E8 | Sufficient evidence is provided for Excellence in this response. The candidate solves the numerical problem economically and accurately. The explanation of the assumptions fails to link the fact that the collision took place on an icy surface to the absence of an external force. The discussion of the effects of bending knees on landing after the jump and of whether momentum is conserved during the jump demonstrates comprehensive understanding of the physics concept of impulse | |
| 3 | A4 | Surprisingly, the candidate does not recognise the existence of the support force of the road - perpendicular to the slope - on the car, nor that weight force is vertically downwards. Inclusion of a drag force down the slope is incorrect. The written explanation of equilibrium is correct but is not supported by a correctly drawn vector diagram. Only one of the three forces acting on the car is correctly calculated. The second calculation is competently done | |
| 4 | E8 | This response affords strong evidence for Excellence. Both numerical solutions are carried out competently and concisely. The application of the concept of an unbalanced force being necessary for circular motion is clearly described in the given context. | |