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**QUALIFY FOR THE FUTURE WORLD**
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# Level 2 Physics, 2017

## 91171 Demonstrate understanding of mechanics

2.00 p.m. Friday 10 November 2017
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.**

**TOTAL**

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## QUESTION ONE: ROLLER SKATING

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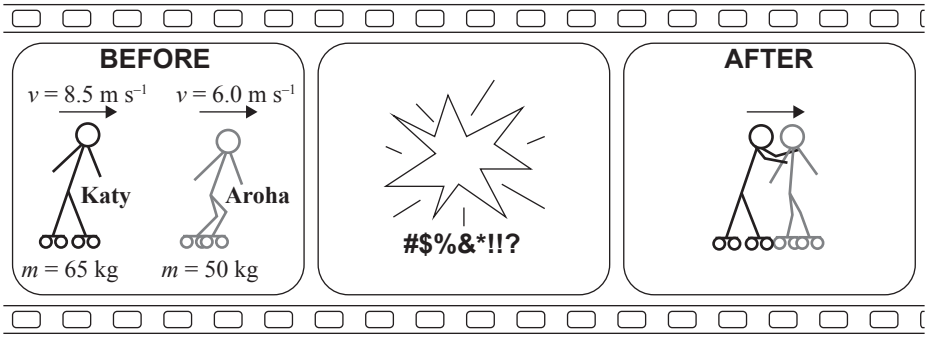
Katy, 65.0 kg, and Aroha, 50.0 kg, are roller skating. Aroha is moving to the right at a constant velocity of 6.0 m $s^{-1}$ and Katy is also moving to the right, behind Aroha, at a constant velocity of 8.5 m $s^{-1}$. Katy collides with Aroha, holds her shoulders, and they move together to the right at a constant velocity.




(a) What physical quantity is conserved during the above inelastic collision between Katy and Aroha?

State any assumptions you have made.

(b) Calculate the combined velocity of Katy and Aroha as they skate together after the collision.

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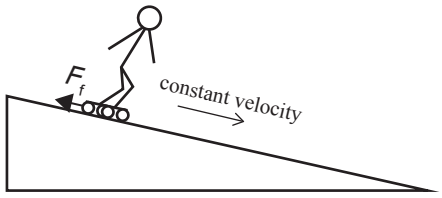
(c) As Katy collides with Aroha, they both experience a force due to the collision. The duration of the collision is 2.5 s.

Calculate the size of the force experienced by Aroha.

(d) Katy goes down a carpeted ramp at a constant velocity. On the diagram below, the friction force, $F_f$, between her skates and the carpet is shown.

(i) Draw and name all other forces acting on Katy.




*If you need to redraw your force diagram, use the diagram on page 8.*

(ii) In the box below, draw a closed vector diagram, showing that forces acting on Katy are balanced.

Name each force.

*If you need to redraw your vector diagram, use the box on page 8.*

## QUESTION TWO: HIGH JUMP

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Sarah, a 55.0 kg athlete, is competing in the high jump where she needs to get her body over the crossbar successfully without hitting it. Where she lands, a padded mattress cushions her fall.

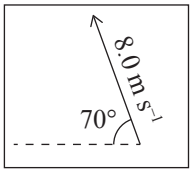
Adapted from: www.britannica.com/sports/high-jump

*If you need to redraw this force diagram, use the box on page 8.*

(a) Calculate the size of the force(s) acting on Sarah just after the take-off, in position 2 in the above diagram.

Draw an arrow(s) in the box to show the direction(s) of the force(s).

(b) During one of the jumps, the initial velocity of Sarah, at take-off, is 8.0 m $s^{-1}$ at an angle of 70° to the horizontal.




Calculate the time it takes for Sarah to reach the maximum height – position 3 in the diagram above.

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After Sarah has jumped, she lies motionless in position 4, as shown in the diagram on the previous page. There are 20 springs evenly spaced in the area of the mattress where she lands. The average compression of each spring is 4.5 cm. Sarah's mass is 55.0 kg.

(c) Calculate the elastic potential energy stored in a single spring of the mattress.

(d) When Sarah lands on the mattress after the jump, the force on her body is quite large.

Discuss TWO changes that could be made to the **springs** of the mattress to make Sarah's landing more comfortable.

Explain any physics principles that should be considered to make these changes.

## QUESTION THREE: A CIRCUS DANCER

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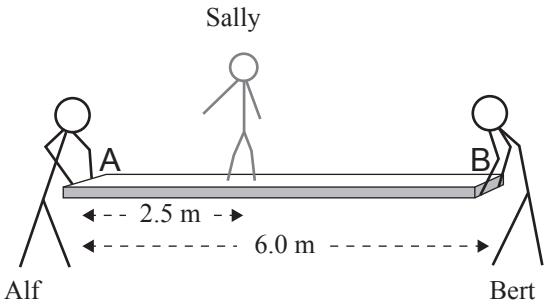
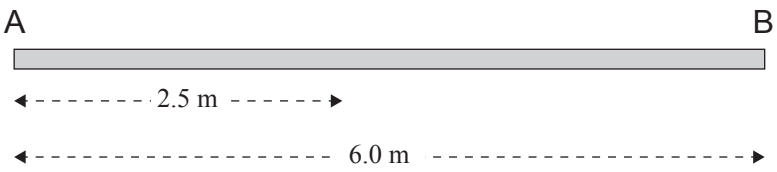



A uniform wooden plank of mass 5.0 kg and length 6.0 m is resting in the hands of two circus employees, Alf and Bert. Sally, a circus dancer of mass 40.0 kg, stands 2.5 m away from end A of the wooden plank, as shown above.

(a) In the diagram below, draw and name all forces acting on the plank.




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

The plank is in a state of equilibrium when Sally is standing still, 2.5 m away from end A of the plank.

(b) (i) Describe the conditions needed for the plank to be in an equilibrium state.

(ii) Calculate the total clockwise torque around end A of the plank

(c) (i) Calculate the size of the force experienced by Alf, who is holding end A of the plank.

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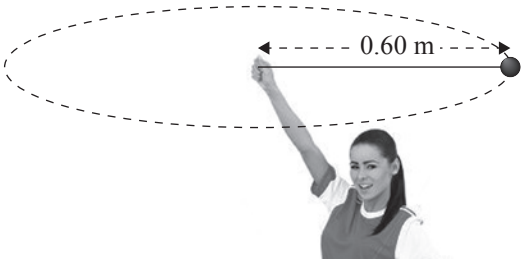
(ii) Explain whether Alf experiences any change in force when Sally moves from her existing position towards end B during her dance routine.

(d) During one of her dance routines, Sally is spinning a ball above her head in a horizontal circle, as shown below.




The ball of mass 0.050 kg makes 5 rotations in 4.0 s. The length of the string from the ball to Sally's hand is 0.60 m.

Calculate the size of the force experienced by the ball during these rotations.

## SPARE DIAGRAMS

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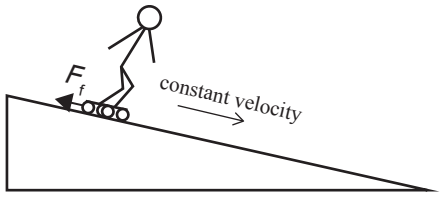
If you need to redraw either of your diagrams for Question One (d), use the diagram and/or box below. Make sure it is clear which diagram you want marked.




If you need to redraw your force diagram for Question Two (a), use the box below. Make sure it is clear which diagram you want marked.

If you need to redraw your force diagram for Question Three (a), use the diagram below. Make sure it is clear which diagram you want marked.

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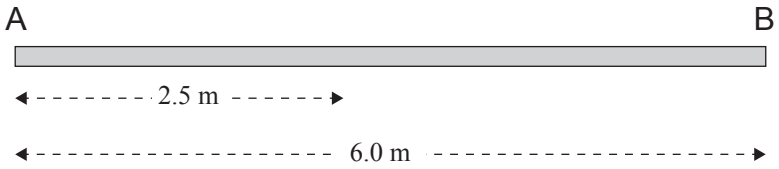

**Extra paper if required.**
**Write the question number(s) if applicable.**

QUESTION NUMBER

ASSESSOR'S USE ONLY

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