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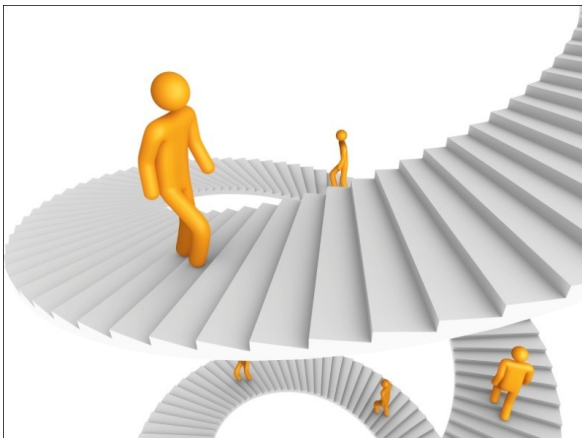
NCEA SCIENCE LEVEL 1

AS 90940 - 1.1
Demonstrate understanding of aspects of Mechanics

Revision Workbook

+

Interactive Web-based Learning



Trevor Castle

www.livewirelearning.co.nz

Introduction

Trevor Castle is the Physics author for the Pathfinder Science series of text books. He was Head of Physics at Palmerston North Boys' High School where he also taught the scholarship/university class.

Live-wire Learning is New Zealand's most comprehensive on-line learning resource for secondary school students providing detailed teaching material and graded questions in Level 1 Science, Level 2 Physics, and Level 3 Physics.

Our aim with this first book in the series is provide complementary hard copy write-on notes and questions to support the on-line material so that, as a student, you get access to the best of both worlds.

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- track your record of learning and your place on the leader board (see our home page)
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We hope that this resource will motivate and equip you to succeed in this subject.

For instructions to access the web site, turn to the inside back cover.

All the best for your exams.

For further information contact
Neil Riley
Live-wire Learning Ltd
editor@livewirelearning.co.nz

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This module discusses: *Force and pressure in the context of everyday experiences and the relationship* $\boldsymbol{P = \frac{F}{A}}$.

Learning Outcomes: *By the end of this module you will be able to*

1. Define mass
2. Recognise the SI unit of mass as the kilogram
3. Define force
4. Recognise the SI unit of force as the newton.
5. Define weight
6. Recognise the SI unit of weight as the newton.
7. Define the gravitational strength acting on an object.
8. Recognise and use the weight formula $F_g = mg$.
8. Define pressure.
9. Recognise and use the pressure formula $P = \frac{F}{A}$ *in the context of everyday experiences.*
10. Recognise the SI unit of pressure as the pascal or newtons per square metre.
11. Recognise the non-SI unit of 1 standard atmosphere.

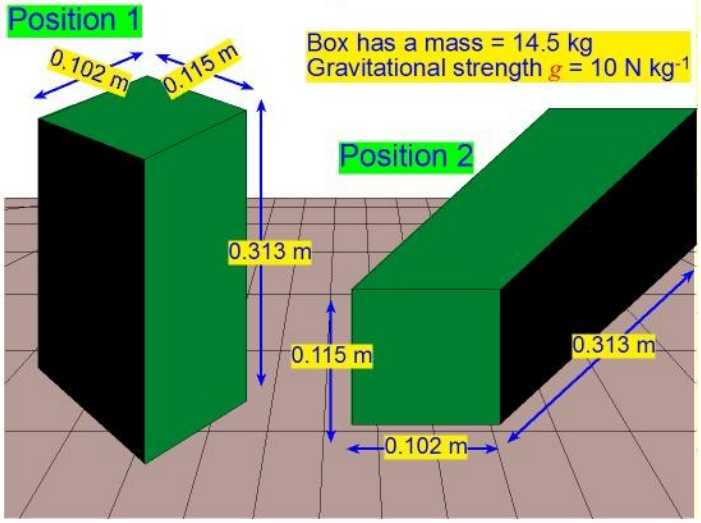
Pressure

Points to Note

A Pressure

Figure 1 shows a box, of mass 14.5 kg, placed in two positions on a floor.

Figure 1: Pressure Exerted by a Box



1. **Mass** *is the measure how much matter an object contains.*
2. The SI unit of mass is the kilogram which has the symbol kg.
3. **Weight** *is the force due to gravity acting on an object.*
4. The SI unit of weight is the newton which has the symbol N.
5. *The gravitational strength g is the gravitational force acting on a unit mass.*
6. The gravitational strength on the Earth's surface, g, is a force of 10 N for each kilogram of mass placed on the Earth's surface, i.e. $g = 10$ N kg^{-1}.
7. The weight formula is

$$F_g = mg$$

Weight = mass x gravitational strength

8. The weight of the box is given by the weight formula $F_g = mg = 14.5 \times 10 = 145$ N.

9. **The number of significant figures in an answer** *is the number of digits, not including any zeros at the beginning but including any zeros at the end of the number.*
10. The answer of 145 has 3 significant figures, abbreviated to 3 sf.

11. *The answer is given to the least accurate of the given data.*

12. The mass is given to 3 sf. and the gravitational strength to 2 sf., so the answer is given to 2 sf.

13. The weight of the box = 150 N to 2 sf.

14. Pressure *is the force per unit area acting on a surface*.

15. The pressure formula is

$$P = \frac{F}{A}$$

$$\text{Pressure} = \frac{\text{force exerted}}{\text{area of surface}}$$

16. The SI unit of force is the newton (N) and the SI unit of area is the square metre (m^2).

17. The SI unit of pressure is newtons per square metre ($N\ m^{-2}$). This is called the pascal, unit symbol Pa.

For position 1:

18. The area of contact of the box with the floor's surface is given by 0.102 x 0.115 = 0.01173 = 0.0117 m^2 to 3 sf.

19. The pressure of the box exerted on the floor's surface is given by

$P = \frac{F}{A} = \frac{145}{0.01173} = 12.361466 \times 10^3 = 12 \times 10^3$ Pa to 2 sf.

For position 2:

20. The area of contact of the box with the floor's surface is given by 0.102 x 0.313 = 0.031926 = 0.0319 m^2 to 3 sf.

21. The pressure of the box exerted on the floor's surface is given by

$P = \frac{F}{A} = \frac{145}{0.031926} = 4.5417528 \times 10^3 = 4.5 \times 10^3$ Pa to 2 sf.

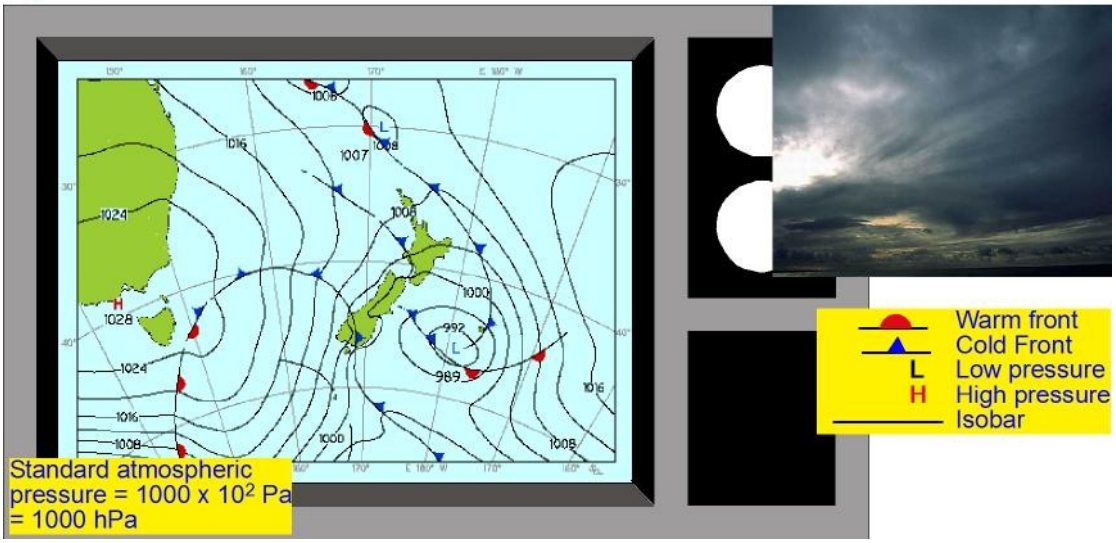
22. Position 2 of the box has a larger area of contact with the floor's surface than position 1 and consequently exerts a smaller pressure.

B Atmospheric Pressure

Figure 2 shows a weather map for New Zealand and the Tasman Sea (as shown on TV).

1. **Atmospheric pressure** *is due to the weight of the air acting on the Earth's Surface.*

Figure 2: Weather Forecast



2. **Standard Atmospheric Pressure** *is a non-SI unit of* pressure = 1.0 x 10^5 Pa to 2 sf.

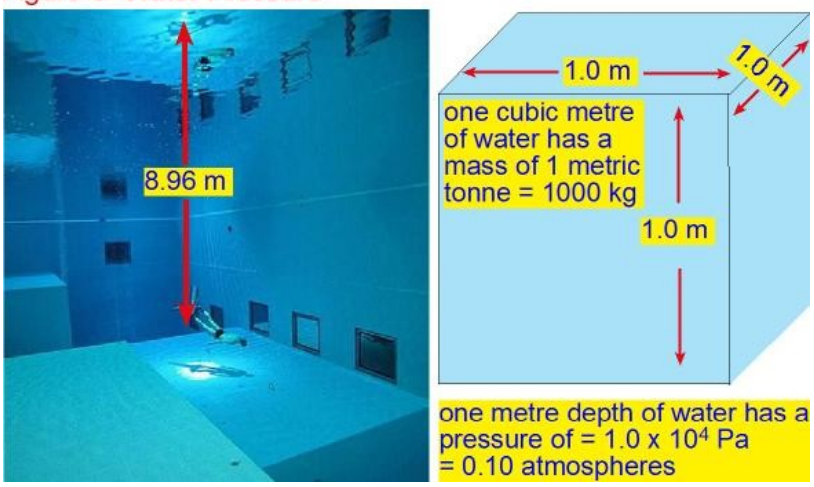
3. The metric prefix "hecto" means 100, symbol h. A standard atmospheric pressure $= \frac{1.0 \times 10^5}{100} =$ 1000 hPa to 2 sf.

4. The pressure of the air above us has small variations above and below one standard atmosphere, *which determines the weather*.
5. **Isobars** *are lines drawn on a weather map indicating equal pressure.*
6. When an air mass forms over land, it is usually dry and does not have any clouds.
7. As the air mass passes over an ocean, it collects evaporated water and clouds form.
8. **A front** *is where warm and cold air meets.*
9. Temperature changes can make air rise or sink. As warm, moist air rises at a *front*, it cools, and clouds form close to a front.
10. A high pressure area (H) is where the air pressure is slightly above normal atmospheric pressure. This is because the air is sinking, is relatively dry and associated with fine weather.
11. A low pressure area (L) is where the air pressure is slightly below normal atmospheric pressure. This is because the air is rising and cools. The water vapour the air carries tends to condense to form clouds and rain, causing wet weather.

C Water Pressure

Figure 3 shows a boy swimming at a depth of 8.96 m in a swimming pool. It also shows a cubic metre of water which has a mass of 1 metric tonne or 1000 kg).

Figure 3: Water Pressure



The cubic metre of water exerts a pressure at its base because of its weight.

1. The weight of the cubic metre of water is given by the weight formula $F_g = mg = 1000 \times 10 = 10\,000$ N to 2 sf.
2. The base area of the cubic metre of water is given by 1.0 x 1.0 = 1.0 m^2 to 2 sf.
3. The pressure of cubic metre of water at its base is given by $P = \frac{F}{A} = \frac{10\,000}{1.0} = 1.0 \times 10^4$ Pa to 2 sf.
4. 1 standard atmosphere = 1.0 x 10^5 Pa to 2 sf.
5. The pressure of cubic metre of water at its base in atmospheres $= \frac{1.0 \times 10^4}{1.0 \times 10^5} =$ 0.10 standard atmospheres to 2 sf.
6. *A depth of 1.0 m of water exerts a pressure of 0.10 standard atmospheres.*
7. The swimmer in the swimming pool has a pressure exerted on him by the water above him, given by the water pressure per metre x number of metres = 0.10 x 8.96 = 0.896 = 0.90 standard atmospheres to 2 sf.
8. The atmosphere above the swimming pool exerts a pressure equal to one standard atmosphere.
9. The total pressure on the swimmer = 1.0 + 0.90 = 1.9 standard atmospheres to 2 sf.
10. With aqua-Lung equipment it is possible to go down to depths of 50 m for short periods.

D Shoe Pressure

Figure 4 shows three examples of girls wearing shoes.

Figure 4: Shoe Pressure

Diagram 1 shows a girl, of mass 56.7 kg, wearing flat shoes.

1. The weight of the girl is given by the weight formula
   $F_g = mg = 56.7 \times 10 = 567 = 570$ N to 2 sf.
2. The base area of the shoe is given by
   $\frac{15.2}{100}$ m $\times \frac{5.4}{100}$ m $= 8.208 \times 10^{-3} = 8.2 \times 10^{-3}$ m^2 to 2 sf.
3. Assuming she puts all her weight on one foot, the pressure exerted by her on the floor is given by $P = \frac{F}{A} = \frac{567}{8.208 \times 10^{-3}} = 6.9078947 \times 10^4 = 6.9 \times 10^4$ Pa to 2 sf.
4. 1 standard atmosphere = 1.0 x 10^5 Pa to 2 sf.
5. The pressure exerted by her on the floor in atmospheres $= \frac{6.9078947 \times 10^4}{1.0 \times 10^5} = 0.6907894 = 0.69$ standard atmospheres to 2 sf.

Diagram 2 shows a girl, of mass 63.4 kg, wearing high-heel shoes.

6. The weight of the girl is given by the weight formula $F_g = mg = 63.4 \times 10 = 634 = 630$ N to 2 sf.
7. The base area of the shoe is given by
   $\frac{1.2}{100}$ m $\times \frac{1.2}{100}$ m $= 1.44 \times 10^{-4} = 1.4 \times 10^{-4}$ m^2 to 2 sf.
8. Assuming she puts all her weight on one heel of a shoe as she walks, the pressure exerted by her on the floor is given by
   $P = \frac{F}{A} = \frac{634}{1.54 \times 10^{-4}} = 4.4027778 \times 10^6 = 4.4 \times 10^6$ Pa to 2 sf.
9. 1 standard atmosphere = 1.0 x 10^5 Pa to 2 sf.
10. The pressure exerted by her on the floor in atmospheres $= \frac{4.4027778 \times 10^6}{1.0 \times 10^5} = 44.027778 = 44$ standard atmospheres to 2 sf.
11. She probably would mark the floor in some way.

Diagram 3 shows a ballerina, of mass 47.8 kg, standing on the points of her toes.

1. The weight of the girl is given by the weight formula $F_g = mg = 47.8 \times 10 = 478 = 480$ N to 2 sf.

2. The base area of the two shoes is given by
   $2 \times \frac{1.4}{100}\ \text{m} \times \frac{1.1}{100}\ \text{m} = 3.08 \times 10^{-4} = 3.1 \times 10^{-4}\ \text{m}^2$ to 2 sf.
3. Assuming she puts all her weight on the two shoes, the pressure exerted by her on the floor is given by $P = \frac{F}{A} = \frac{478}{3.08 \times 10^{-4}} = 1.5519481 \times 10^6 = 1.6 \times 10^6$ Pa to 2 sf.
4. 1 standard atmosphere = 1.0×10^5 Pa to 2 sf.
5. The pressure exerted by her on the floor in atmospheres $= \frac{1.5519481 \times 10^6}{1.0 \times 10^5} =$ $15.519481 = 16$ standard atmospheres to 2 sf.

Notes

COMPUTER WORK

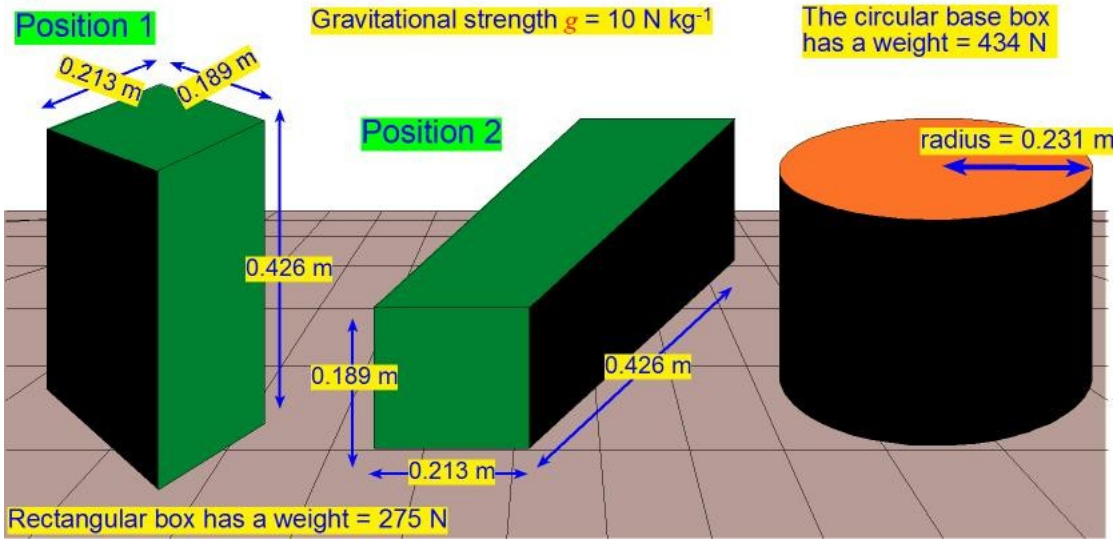
Log on to Live-wire Learning and answer the questions.

MODULE	First Attempt /10	Working at	Second Attempt /10	Working at
Pressure – AO				
Pressure				

Merit Level Questions

Q. 1. Figure 6 shows a rectangular box in two positions and a circular base box of radius 0.231 m.

Figure 6: Pressure Exerted by a Box



a) What is the pressure the rectangular box exerts on the floor's surface in position 1 in SI units to 3 sf.?

b) What is the pressure the circular base box exerts on the floor's surface in SI units to 3 sf.? (The formula for the area of circle is $A = \pi r^2$)

Q. 2. Figure 9 shows a girl ice skating, of weight (including her skates) = 789 N. The area of a blade of each ice skate = 16.8 cm by 0.75 cm.

a) What is the area of an ice skate blade in SI units to 3 sf.?

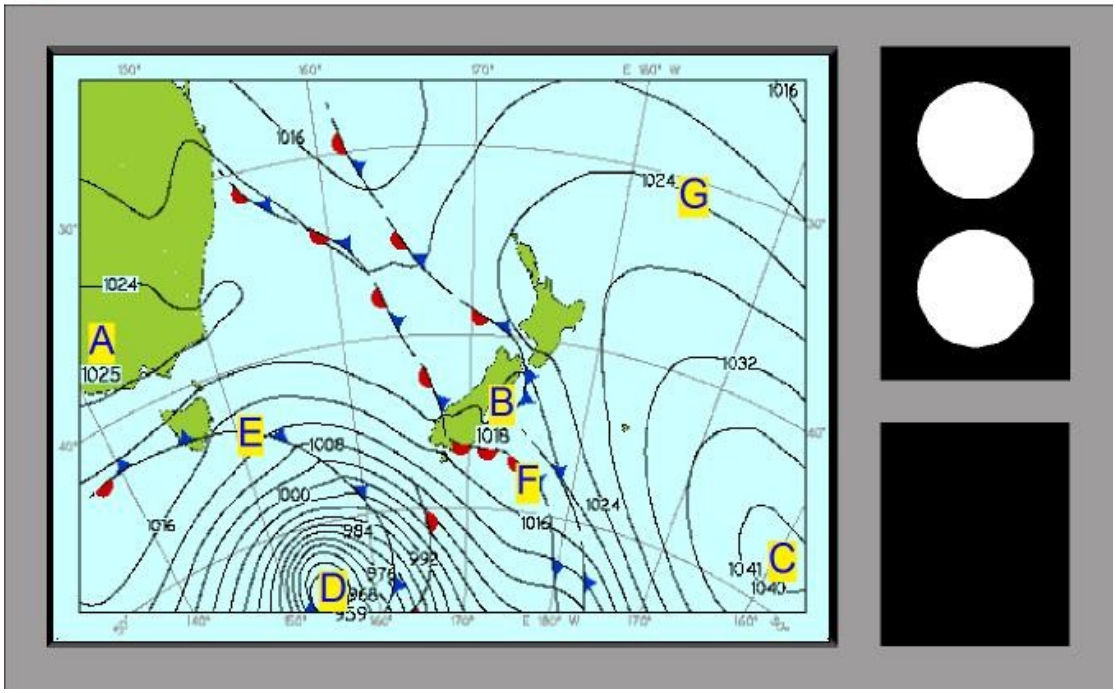
Figure 9: Ice Skater

b) Assuming all her weight is on one ice skate, what is the pressure exerted by her on the ice surface, in SI units to 2 sf.?

Excellence Level Questions

Q. 1. Figure 7 shows a weather map for New Zealand and the Tasman Sea (as shown on TV). Various points are labeled A to G.

Figure 7: TV Weather Forecast



a) Describe the air pressure at point C.

b) Describe what is happening to the air at point C.

c) Describe the type of weather to be expected at point C.

Q. 2. Figure 11 shows a hurdler, of weight = 989 N, about to land on one foot after jumping over a hurdle. The foot area = 16.8 cm by 126 mm.

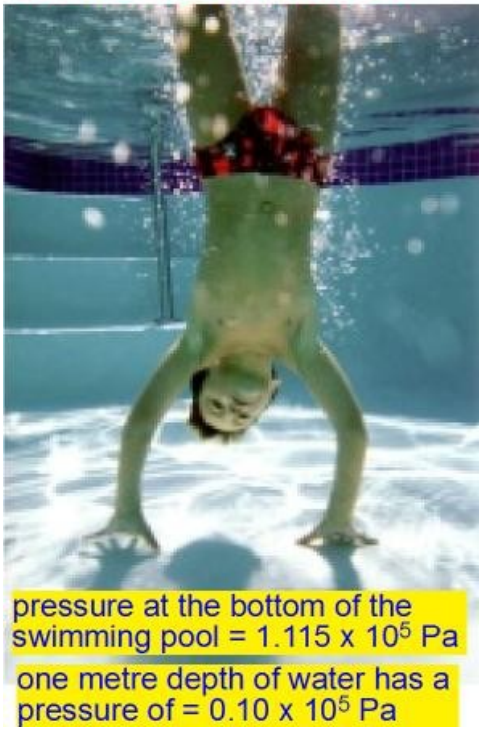
Figure 11: Hurdler

a) What is the area of his foot in SI units to the appropriate number of significant figures?

b) What is the pressure exerted on the ground surface by his foot as he lands, in standard atmospheres to 3 sf.? (1 standard atmosphere = 1.013×10^5 Pa)

Q. 3. Figure 8 shows a boy swimming in a swimming pool. The *total* pressure at the bottom of the swimming pool = 1.115×10^5 Pa. The atmospheric pressure above the pool = 1.013×10^5 Pa. (One metre depth of water has a pressure of 0.10×10^5 Pa to 2 sf.)

Figure 8: Water Pressure at the Bottom of a Swimming Pool



a) What is the pressure at the bottom of the swimming pool due to the water in the pool only, in SI units, to the appropriate number of significant figures?

b) What is the pressure at the bottom of the swimming pool due to the water in the pool only, in standard atmospheres, to the appropriate number of significant figures? (1 standard atmosphere = 1.0×10^5 Pa to 2 sf.)

c) What is the depth of the swimming pool, in SI units, to the appropriate number of significant figures?

ANSWERS
PRESSURE

Merit Level Questions

Q. 1. Figure 6 shows a rectangular box in two positions and a circular base box of radius 0.231 m.

a) What is the pressure the rectangular box exerts on the floor's surface in position 1 in SI units to 3 sf.?

- The area of the rectangular box in contact with the floor in position 1 is given by 0.213 x 0.189 = 0.040257 m^2.
- The pressure of the rectangular box exerted on the floor's surface in position 1 is given by $P = \frac{F}{A} = \frac{275}{0.040257} = 6831.1101 = 6830$ Pa to 3 sf.

b) What is the pressure the circular base box exerts on the floor's surface in SI units to 3 sf.? (The formula for the area of circle is $A = \pi r^2$)

- The area of the circular base box in contact with the floor is given by $A = \pi r^2 = \pi(0.231)^2 = 0.1676385\ m^2$.
- The pressure of the circular base box exerted on the floor's surface is given by $P = \frac{F}{A} = \frac{434}{0.1676385} = 2588.9041 = 2590$ Pa to 3 sf.

Q. 2. Figure 9 shows a girl ice skating, of weight (including her skates) = 789 N. The area of a blade of each ice skate = 16.8 cm by 0.75 cm.

a) What is the area of an ice skate blade in SI units to 3 sf.?

- The area of an ice skate blade is given by $\frac{16.8}{100}\ m \times \frac{0.75}{100}\ m = 1.26 \times 10^{-3}\ m^2$ to 3 sf.

b) Assuming all her weight is on one ice skate, what is the pressure exerted by her on the ice surface, in SI units to 2 sf.?

- The pressure exerted by her on the ice surface is given by $P = \frac{F}{A} = \frac{789}{1.26 \times 10^{-3}} = 6.2619048 \times 10^5 = 6.3 \times 10^5$ Pa to 2 sf.

Excellence Level Questions

Q. 1. Figure 7 shows a weather map for New Zealand and the Tasman Sea (as shown on TV). Various points are labeled A to G.

a) Describe the air pressure at point C.
- Point C is a high pressure area (H) is where the air pressure is slightly above normal atmospheric pressure.

b) Describe what is happening to the air at point C.
- The air is sinking.

c) Describe the type of weather to be expected at point C.
- The air is relatively dry and associated with fine weather.

Q. 2. Figure 11 shows a hurdler, of weight = 989 N, about to land on one foot after jumping over a hurdle. The foot area = 16.8 cm by 126 mm.

a) What is the area of his foot in SI units to the appropriate number of significant figures?

- The foot area is given by $\frac{16.8}{100}\ m \times \frac{126}{1000}\ m = 0.021168\ m^2 = 0.0212\ m^2$ to 3 sf.

b) What is the pressure exerted on the ground surface by his foot as he lands, in standard atmospheres to 3 sf.? (1 standard atmosphere = 1.013 x 10^5 Pa)

- 0.461 standard atmospheres.
- The pressure exerted on the ground surface by his foot is given by

$P = \frac{F}{A} = \frac{989}{0.021168} = 0.46721466 \times 10^5$ Pa $= \frac{0.46721466 \times 10^5}{1.013 \times 10^5} = 0.4612188 =$ 0.461 standard atmospheres to 3 sf.

Q. 3. Figure 8 shows a boy swimming in a swimming pool. The *total* pressure at the bottom of the

swimming pool = 1.115 x 10^5 Pa. The atmospheric pressure above the pool = 1.013 x 10^5 Pa. (One metre depth of water has a pressure of 0.10 x 10^5 Pa to 2 sf.)

a) What is the pressure at the bottom of the swimming pool due to the water in the pool only, in SI units, to the appropriate number of significant figures?

- The pressure at the bottom of the swimming pool due to the water in the pool only = total pressure – atmospheric pressure = 1.115 x 10^5 - 1.013 x 10^5 = 0.102 x 10^5 Pa to 3 sf.

b) What is the pressure at the bottom of the swimming pool due to the water in the pool only, in standard atmospheres, to the appropriate number of significant figures? (1 standard atmosphere = 1.0 x 10^5 Pa to 2 sf.)

- The pressure at the bottom of the swimming pool due to the water in the pool only, in standard atmospheres $= \frac{0.102\times10^5}{1.0\times10^5} = 0.102 = 0.10$ standard atmospheres to 2 sf.

c) What is the depth of the swimming pool, in SI units, to the appropriate number of significant figures?

- The depth of the swimming pool $= \frac{0.102\times10^5}{0.10\times10^5} = 1.02 = 1.0$ m to 2 sf.