VANCOUVER 2010 OLYMPIC MATH TRAIL
SOLUTIONS

QUESTION 1 - Flight Travel Time

What time should Kenji and Yumi's flight arrive in Vancouver?

Tokyo → (8800 km, 10 hours) → LA (+2 hour stop) → (1749 km, 1hr 59 mins) → Vancouver

= 13 hrs 59 minutes total travel time

Arrival Time = 12:59 pm on Monday (Tokyo Time)
= 8:59 pm on Sunday (Vancouver Time)

QUESTION 2 – Money Conversion

What is the Canadian equivalent of ¥1, $1 HKD and ₤1?

$$¥1 = \frac{\$1\text{ CDN}}{¥86.33} = \$0.0116\text{ CDN}$$

$$\$1\text{ HKD} = \frac{\$1\text{ CDN}}{\$5.62\text{ HKD}} = \$0.178\text{ CDN}$$

$$£1 = \frac{\$1\text{ CDN}}{£0.44} = \$2.27\text{ CDN}$$

Which traveler has the largest Canadian value of money in their pocket?

Kenji: $\frac{¥7338}{¥86.33} \approx \$85\text{ CDN}$

Paul: $\frac{£36}{£0.44} \approx \$82\text{ CDN}$

Jenny: $\frac{\$494\text{ HKD}}{\$5.62\text{ HKD}} \approx \$88\text{ CDN}$

Jenny has the largest value of money in Canadian dollars.

QUESTION 3 – Taxi Ride

How much will Kenji and Yumi pay for the taxi ride?

Airport —15km→ Jenny's Hotel —5km→ Kenji and Yumi's Hotel

$$\text{Taxi Cost} = \$3.50 + \frac{((20*1000) - 74.6))}{74.6} * .12 + \frac{(4*60)}{15} * .12$$

Taxi Cost = \$3.50 + \$32.05 + \$1.92 = \$37.47

Taxi Cost + Tip = 1.15 * \$37.47 = **\$39.64**

QUESTION 4 - GM Place Seating Capacity

How many seats are in the Balcony?

First, find the number of seats in the Plaza level using the given information.

$$22 \text{ sections} \times 25 \frac{\text{rows}}{\text{section}} \times 20 \frac{\text{seats}}{\text{row}} = 11{,}000 \text{ seats}$$

Next, simply subtract this number from the total seating capacity.

20,000 - 11,000 = **9000 seats in the Balcony**

QUESTION 5 - Hockey Game Revenue

How much revenue could this Canada-USA game generate if all 20,000 seats are filled?

Plaza: $^{10}/_{22}$ x 11,000 = 5000 seats x \$350/seat = \$1,750,000
11,000 - 5000 = 6000 seats x \$300/seat = \$1,800,000

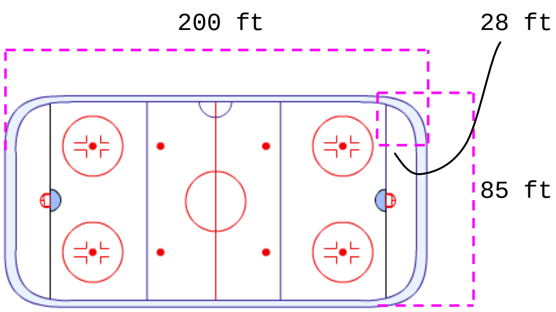
Balcony: $^{1}/_{3}$ x 9000 = 3000 seats x \$250/seat = \$750,000
$^{2}/_{5}$ x 9000 = 3600 seats x \$200/seat = \$720,000
9000 - (3000 + 3600) = 2400 seats x \$150/seat = \$360,000

Total revenue = **\$5,380,000 or \$5.38 million**

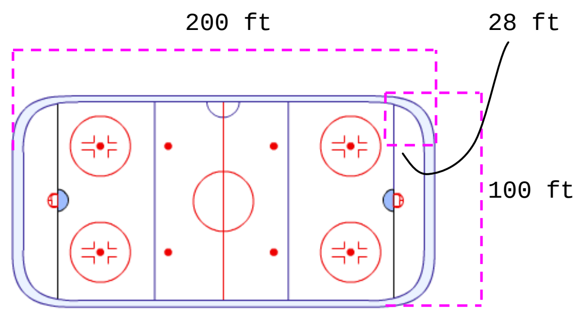
QUESTION 6 - Ice Rink Surface Area

What is the difference in surface area between the NHL size and the Olympic (international) size? Conversion: 1 ft = 0.3048 m

NHL size rink

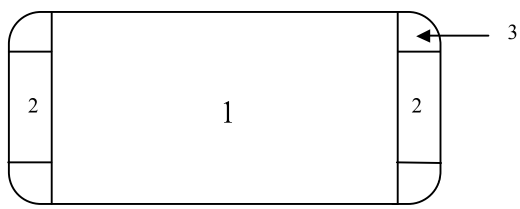


Olympic (international) size rink



There are two methods to solving this problem.

Solution A: Break the rink into sections and find the surface area of each section, then add all the areas to find the total surface area. Remember to convert your answer to squared metres (m^2).



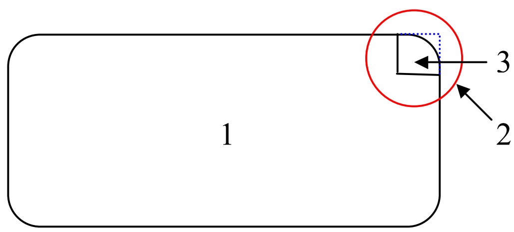
NHL ice rink	Olympic (international) ice rink
Section 1:	
Length = 200 - (2 x 28) = 144 ft Width = 85 ft Area = 144 x 85 = 12,240 ft^2	Length = 200 - (2 x 28) = 144 ft Width = 100 ft Area = 144 x 100 = 14,400 ft^2
Section 2:	
Length = 85 - (2 x 28) = 29 ft Width = 28 ft Area = 29 x 28 = 812 x 2 = 1624 ft^2	Length = 100 - (2 x 28) = 44 ft Width = 28 ft Area = 44 x 28 = 1232 x 2 = 2464 ft^2
Section 3:	4 quarter circles = 1 circle Radius = 28 ft Area = $\pi r^2 = \pi(28)^2 \approx 2463$ ft^2

Total surface area of rink:	
$12,240 + 1624 + 2463 = 16,327\ ft^2$	$14,400 + 2464 + 2463 = 19,327\ ft^2$
Using the conversion factor: 1 ft = 0.3048 m, we get $1\ ft^2 \approx 0.0929\ m^2$	
$16,327\ ft^2 \times \frac{0.0929\ m^2}{1\ ft^2} = 1516.83\ m^2$	$19,327\ ft^2 \times \frac{0.0929\ m^2}{1\ ft^2} = 1795.54\ m^2$

The surface area of the international ice rink is approximately **278.71 m^2 bigger** than the NHL ice rink.

Alternatively, you can convert the units to metres first then solve for the surface area.

Solution B: Close the corners of the rink to form a rectangle and find the area. Then subtract the area that lies outside the quarter circles. Remember to convert your answer to m^2.



NHL ice rink	Olympic (international) ice rink
Section 1:	
Length = 200 ft, Width = 85 ft Area = 200 x 85 = 17,000 ft^2	Length = 200 ft, Width = 100 ft Area = 200 x 100 = 20,000 ft^2
Section 2: Area of four square corners = $28^2 \times 4 = 3136\ ft^2$	
Section 3: 4 quarter circles = 1 circle Radius = 28 ft Area = $\pi r^2 = \pi(28)^2 \approx 2463\ ft^2$	
Subtract area of quarter circles (sec.3) from square corners (sec.2): $3136 - 2463 = 673\ ft^2$	
Total surface area of rink:	
$17,000 - 673 = 16,327\ ft^2$	$20,000 - 673 = 19,327\ ft^2$

We see that solution B will give the same answer. Again, you can convert the units to metres first then solve.

QUESTION 7 – Perimeter of Ice Rink

How much more board length is required to surround the perimeter of the international rink than the NHL rink? Write your answer in metres.

NHL ice rink	International ice rink
Sides (horizontal): 200 – (2 x 28) = 144 x 2 = 288 ft	
Sides (vertical):	
85 – (2 x 28) = 29 x 2 = 58 ft	100 – (2 x 28) = 44 x 2 = 88 ft
Circumference of circle: Radius = 28 ft, $C = 2\pi r = 2\pi(28) = 56\pi \approx 175.93$	
Total perimeter of ice rink:	
288 + 58 + 175.93 = 521.93 ft	288 + 88 + 175.93 = 551.93 ft
Using the conversion factor 1 ft = 0.3048 m, we get	
$521.93 \text{ ft} \times \frac{0.3048 \text{ m}}{1 \text{ ft}} = 159.08 \text{ m}$	$551.93 \text{ ft} \times \frac{0.3048 \text{ m}}{1 \text{ ft}} = 168.23 \text{ m}$

The international ice rink requires approximately **9.15 m** more board length than the NHL ice rink.

QUESTION 8 - Temperature of Ice

$$F = \frac{9}{5}C + 32$$

Isolate C and then substitute F into the formula to solve the problem.

$F = (^9/_5)C + 32$

Subtract 32: $F - 32 = (^9/_5)C$

Multiply by $^5/_9$: $(^5/_9)(F - 32) = C$

Rewrite the formula as: $C = (^5/_9)(F - 32)$

Now, substitute 24°F and 26°F into the formula to find the equivalent in degrees Celsius.

$C = (^5/_9)(24 - 32) = -4.4$ $\quad$ $C = (^5/_9)(26 - 32) = -3.3$

The temperature of the ice is **between -4.4 and -3.3°C**.

QUESTION 9 - How heavy are they?

a) *The Mean*: To find the mean weight of the team we must add up the weight of all players and divide by the total number of players. In this case the player weights add up to 4462 lbs and there are 23 players. Therefore, 4462 divided by 23 is equal to 194 lbs. The mean is **194 lbs.**

b) *The Median*: To find the median we must first list the weights in order from least to greatest. For example, 173 lbs would be the first weight listed since it is the smallest and 236 lbs would be the last weight listed since it is the smallest. The median is the middle of the distribution. In other words, half the weights are above the median and half the weights are below the median. The weight in the middle is **205 lbs**. This is the median.

c) *The Mode*: To find the mode we must find the weight that occurs most frequently. In this case the mode is **220 lbs.**

QUESTION 10 - A New Team Member

If a new player is added to the team this makes the total number of players equal to 24. Let's represent the new player's weight by x. This means that the sum of all the players $(4462 + x)$ divided by the number of players (24) must give us 3 lbs more than the previous average (197 lbs). The equation is as follows:

$$(4462 + x) / 24 = 197$$

Solving for x gives us **266 lbs**.

QUESTION 11 - Skating Around the Rink

In 10 seconds Joe does a fraction of 10/16 of the track, so Owen does 6/16, that is, 3/8 of the track. We know this because when they meet they skate one complete lap between the two of them so the fraction they each have done must add to one.

To do 1/8 of the track Owen will take 10/3 seconds. To do 8/8 (or one whole lap) he will take 80/3 seconds, or **26.67 seconds**.

QUESTION 12 - How fast are they going?

From Question 7, we know that the perimeter of the rink is approximately 168.23 metres. To find out how many metres/second each player is going, let's divide the distance by their time.

Joe: speed = 168.23m/16s = 10.51 m/s
Owen: speed = 168.23m/26.67s = 6.31 m/s

Now we must convert m/s to km/hr. We know that there are 1000 metres in a kilometre so we must divide our answer by 1000 to get it in kilometres. Also, we know that there are 60 seconds in a minute and 60 minutes in an hour, so we must multiply our answer by 60 x 60, which is 3600. Lets do that now.

Joe: (10.51 x 3600) / 1000 = **37.84 km/h**
Owen: (6.31 x 3600) / 1000 = **22.72 km/h**

QUESTION 13 - How many rotations?

The length of the rink is 200 ft long. To figure out this question we must first figure out the circumference of the puck. We know that circumference is equal to π times the diameter of the puck ($C = \pi d$). If the puck has a 3-inch diameter then the circumference is 3π inches. Before we use our result we must make sure that we are dealing with the same units. We know that there are 12 inches per foot, so this gives us 2400 inches for the length of the rink.

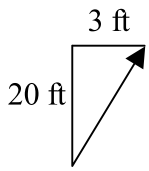
To find out how many rotations the puck makes we can divide the total distance (2400 inches) by the circumference (3π inches) which gives us **255 rotations**.

QUESTION 14 - Puck Travel Time

We are given the speed at which the puck travels (98.9 miles/hr) and we are given the length of the rink it travels (200 ft). First let us use the conversions to get both values with the same units. To convert 200 feet to metres we must multiply it by 0.3048. This gives us a rink length of 60.96 metres. We know that there are 1609.344 metres per mile; therefore, there are 60.96 metres per 0.03787878… miles. We can solve this by setting up fractions and solving for x number of miles. Distance = Speed x Time, so to solve for time we must divide the distance by the speed. Divide 0.03787878… miles by 98.9 miles per hour. This gives us 0.000383 hours. Since there are 60 minutes in an hour and 60 seconds in a minute we must multiply this number by 60 x 60 (or 3600). The final answer is **1.38 seconds**.

QUESTION 15 - The Angle of the Shot

Lori is standing 20 feet from the middle of the net. Also, the goalpost is 3 feet to the side of the net. We can use trigonometry to find the angle. Here is a picture.



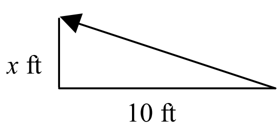
We know that tan θ = opposite side/ adjacent side = 3/20 and so **θ = 8.53 degrees**

QUESTION 16 - Does the angle change?

This time Lori is 40 feet from the middle of the net because she moves back 20 feet. The angle that she shoots at is expected to decrease because she is further away. If she had moved closer the angle would have increased. The calculations are similar to the question above.
Tan θ = opposite side/ adjacent side = 3/40 and so **θ = 4.29 degrees** - just over half as large as with her first shot from 20 feet.

QUESTION 17 - Does she score?

Let's take a side view of Lori's third shot. She shoots the puck toward the net at an angle of 30º. This angle is located at the bottom right hand side of the triangle below.



To find out what the height of her shot is we use trigonometry.

Tan 30º = opposite side/adjacent side = $x/10$ and so $x = 5.77$ ft. This means that when the puck reaches the net it is at a height of 5.77 ft. **She does not score a goal**. Since the net is only 4 feet high Lori overshoots the puck by **1.77 ft**.

QUESTION 18 - Transportation to and from Whistler

Based on cost, which method of transportation should Kenji and Yumi choose for their trip to Whistler?

Vancouver —121 km→ Whistler —121 km→ Vancouver

$$\text{Option A} = 100 + (242 * .2) + \frac{(242)}{12.5} * .76 + 20$$

Option A = \$100 + \$48.40 + \$14.71 + \$20 = \$183.11

Option B = \$95 * 2 = \$190

Our travelers will choose to rent the car and save \$190 - \$183.11 = \$6.89

QUESTION 19 – How much has Whistler grown?

In 1996, Whistler had a population of 7,172 which grew to 8,894 in 2001. How much did Whistler's population grow by between 1996 and 2001?

$$\%\ growth = \left[\frac{new\ population}{old\ population} - 1\right] \times 100\%$$

$$= \left[\frac{8{,}894}{7{,}172} - 1\right] \times 100 = 24\%$$

QUESTION 20 – What is Whistler's population?

If the population increases by 35% between 2001 and 2010, what would Whistler's population be in 2010?

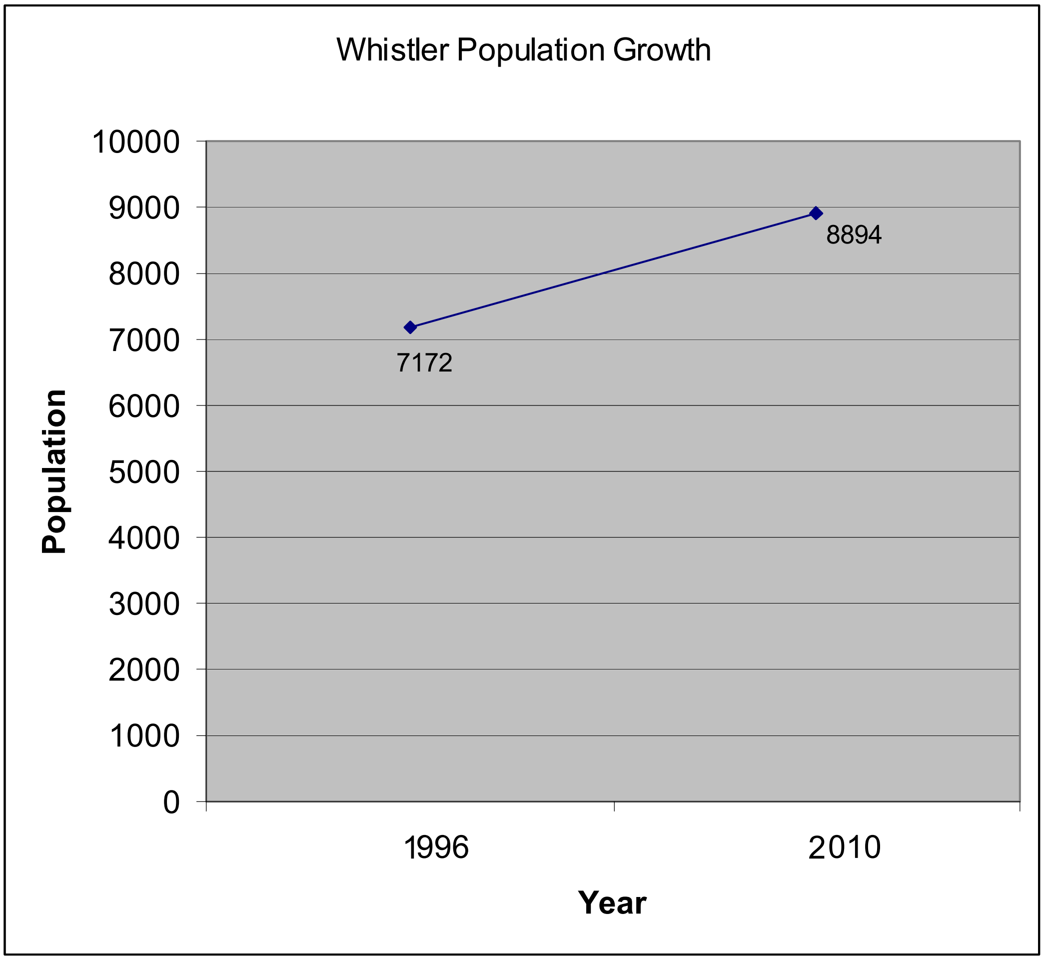
$$new\ population = old\ population\left[\frac{\%growth}{100} + 1\right]$$

$$= 8{,}894\left[\frac{35}{100} + 1\right]$$

$$= 12{,}007\ people$$

QUESTION 21 – Graph It

Construct a graph of population vs. year using the given data for 1996 and 2001.



QUESTION 22 – What is the slope and what does it mean?

$$m = \frac{y_1 - y_2}{x_1 - x_2}$$

$$m = \frac{8,894 - 7,172}{2001 - 1996} = 344.4 \textit{ people per year}$$

QUESTION 23 – A Counting Problem

Let DH represent the percentage of skiers who participate in the Downhill
Let SG represent the percentage of skiers who participate in the Super-G
Let S represent the percentage of skiers who participate in the Slalom

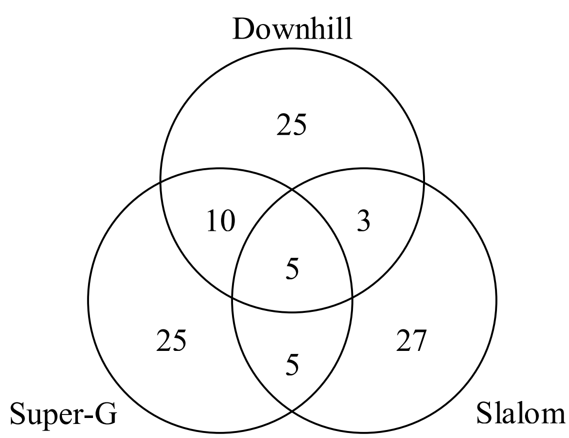
Then if one adds these numbers: $43 + 45 + 40 = 128$ meaning 28 percent of the skiers are counted more than once.

Then one adds $DH \cap SG + SG \cap S + S \cap DH$: $15 + 10 + 8 = 33$ meaning 33 percent of the skiers participate in more than one event.

Therefore, the difference between these totals is the amount of skiers who have been counted more than two times.

Therefore, the number of skiers who compete in all three events is 5 percent.

Working with a Venn diagram, one can determine that the number of **skiers who compete in exactly two events is 18 percent**.



QUESTION 24 – Find the Angle

$$\sin x = \frac{\text{opposite}}{\text{hypotenuse}}$$

<u>Men</u>

$$\sin x = \frac{883m}{3016m}$$

$$x = \arcsin(\frac{883}{3016})$$

$$x \approx 17.02^\circ$$

<u>Women</u>

$$\sin x = \frac{880m}{3140m}$$

$$x = \arcsin(\frac{880}{3140})$$

$$x \approx 16.27^\circ$$

QUESTION 25 – As fast as a speeding car?

$$speed = \frac{distance}{time}$$

(a) Calculate Carole Montillet's speed in km/h.

Distance = 3140 m, Time = 69.56 s

$$\frac{3,140m}{69.56s} \times \frac{3600s}{1h} \times \frac{1km}{1000m} = 162.5\ km/h$$

(b) Calculate Fritz Strobl's speed in km/h.

Distance = 3016 m, Time = 69.13 s

$$\frac{3,016m}{69.13s} \times \frac{3600s}{1h} \times \frac{1km}{1000m} = 157.1\ km/h$$

QUESTION 26 – What is the radius and length of the curves of the speed skating track?

Let D be the total distance of the race
Let a & e be the straight legs of the race
Let c be the crossover distance
Let d be the length of the smaller semi-circle
Let b be the length of the larger semi-circle

Then,

$$D = a + b + c + d + e$$

with,

a = 112 m and e = 112 m

Therefore,

500 m = 112 m + b + c + d + 112 m
276 m = b + c + d

Now using the Pythagorean Theorem, one can obtain length c

$$c^2 = (112m)^2 + (5m)^2$$
$$c^2 = 12569m^2$$
$$c = \sqrt{12569m^2}$$
$$c \approx 112.11m$$

So,

$$276\text{ m} = b + 112.11\text{ m} + d$$
$$163.89\text{ m} = b + d$$

Now one must calculate the circumference (i.e. length) of the two semi-circles.

Recall: Circumference = $2\pi r$

Now, let r be the radius of the smaller semi-circle

Then, the larger semi-circle is $r + 5$

Thus,

$$\frac{1}{2}(2\pi r) + \frac{1}{2}(2\pi[r+5]) = 163.89m$$

$$\frac{1}{2}(2\pi r + 2\pi[r+5]) = 163.89m$$

$$\frac{2\pi}{2}(r + r + 5) = 163.89m$$

$$2r + 5 = \frac{163.89m}{\pi}$$

$$r = \frac{1}{2}\left(\frac{163.89m}{\pi} - 5\right)$$

$$r \approx 23.58m$$

Therefore, the small semi-circle has a radius of 23.58m and the larger semi-circle has a radius of 28.58m.

Now we can use these radii to obtain the length of the semi-circles.

$$d = \frac{1}{2}(2\pi[23.58m])$$
$$d \approx 74.09m$$

$$b = \frac{1}{2}(2\pi[28.58m])$$
$$b \approx 89.80m$$

QUESTION 27 –What is the surface area of a speed skating oval?

Let SA be the total surface area of the speed skating oval
Let SA_r be the total surface area of the rectangle portions of the speed skating oval
Let SA_c be the total surface area of the circular portion of the speed skating oval

Therefore, $SA = SA_r + SA_c$

Now, $SA_r = 2(112m)(15m)$
$SA_r = 3360m^2$

If one uses the radii calculated above it is easy to see the larger circle will have

$Radius_{large} = r$ (from above) + 10m

and the smaller circle will have

$Radius_{small} = r$ (from above) – 5m

and the difference between these two areas is the area we seek.

$$SA_{large} = \pi r^2$$
$$= (33.584m)^2\pi$$
$$= 1127.885\pi \text{ m}^2$$

$$SA_{small} = (18.584m)^2\pi$$
$$= 345.365\pi \text{ m}^2$$

Therefore, $SA_c = 1127.885\pi \text{ m}^2 - 345.365\pi \text{ m}^2$
$= 782.52\pi \text{ m}^2$

Therefore, $SA = 3360 \text{ m}^2 + 782.52\pi \text{ m}^2$
$\approx \mathbf{5818.357\ m^2}$

QUESTION 28 – How much water is needed to make a speed skating oval?

Let V be the volume of the speed skating ice.

Since we are given the thickness in centimetres we must convert this number into metres.

Conversion: 100 cm = 1 m

$$V = SA(2 \text{ cm})$$

$$V = SA(2cm)\left(\frac{1m}{100cm}\right)$$

$$V = 5818.357 \text{ m}^2 (0.02 \text{ m})$$

$$\mathbf{V = 116.367\ m^3}$$

QUESTION 29 – A Regression Analysis Problem

Answers may vary

Performing a regression analysis with the last two digits of the year prior to the year 2000 and then using the 100+ last two digits after the year 2000, a sample regression would be

Olympic Record Time = -0.11917 (year) + 47.42905

Therefore, the Olympic record speed for the 500m speed skating during the 2010 Winter Olympics would be…

Olympic Record Time = -0.11917 (110) + 47.42905

Olympic Record Time = 34.32035 seconds

QUESTION 30 – How fast does a speed skater travel?

Recall: $speed = \frac{dis\tan ce}{time}$

Therefore, the Olympic speed skater's record-holding speed is…

$$speed = \frac{500m}{34.32\sec}$$

$$= 14.57\frac{m}{\sec}$$

Now to convert this into kilometres per hour

$$speed = \left(14.57\frac{m}{\sec}\right)\left(\frac{1km}{1000m}\right)\left(\frac{60\sec}{1\min}\right)\left(\frac{60\min}{1hr}\right)$$

speed = 52.45 km/h

QUESTION 31 – How fast can these athletes get there?

	Prince George (780 km)	Kamloops (355 km)	Cranbrook (845 km)	Whistler (125 km)
Speed Skater (52.45 km/hr)	14.87 hours	6.77 hours	16.11 hours	2.38 hours
Speed Skater (HH:MM:SS)	14:52:12	06:46:12	16:06:36	02:22:48
Hockey Player (37.84 km/hr)	20.61 hours	9.38 hours	22.33 hours	3.30 hours
Hockey Player (HH:MM:SS)	20:36:36	09:22:48	22:19:48	03:18:00
Downhill Skier (162.5 km/hr)	4.8 hours	2.18 hours	5.2 hours	0.77 hours
Downhill Skier (HH:MM:SS)	04:48:00	02:10:48	05:12:00	00:46:12

Note: $time = \frac{distance}{speed}$

QUESTION 32 – Budget versus Actual Cost

How much money do you calculate that Kenji and Yumi will need for their trip? What is the difference between your calculation and Kenji and Yumi's calculation?

Taxi Ride	$39.64
Golf ((65*2) + 22.5 + 40) * 1.145 =	$220.41
Day 2 Lunch and Taxi (28 + 15) * 1.15 =	$49.45
Program	$8.00
Hockey Food	$20
Jersey 200 * 1.145 =	$229
Post Game Dinner (145.76 * .8) * 1.15 =	$134.10
Whistler Transportation	$183.11
Hotel Store Food	$7
Day 3 Lunch (33.5 * 1.15) =	$38.53
Memorabilia	$112
Day 3 Dinner 32.35 * 1.15 =	$37.20
Transportation to Capilano	$22
Day 4 Lunch	$22
Park Fees (16.95 * 2) * 1.145 =	$38.82
Hotel 375 * 1.145 =	$772.89
Total Cost	**$1934.15**

Our travelers have spent $234.15 more dollars than the $1700 they had budgeted.

QUESTION 33 - Equations of the Olympic Rings

Working from the left to the right with the outer ring listed first.

Ring	1 larger	1 smaller	2 larger	2 smaller
Standard	$x^2+(y-4)^2=16$	$x^2+(y-4)^2=9$	$(x-4)^2+y^2=16$	$(x-4)^2+y^2=9$
Function	$y=\sqrt{16-x^2}+4$ $y=-\sqrt{16-x^2}+4$	$y=\sqrt{9-x^2}+4$ $y=-\sqrt{9-x^2}+4$	$y=\sqrt{16-(x-4)^2}$ $y=-\sqrt{16-(x-4)^2}$	$y=\sqrt{9-(x-4)^2}$ $y=-\sqrt{9-(x-4)^2}$

Ring	3 larger	3 smaller	4 larger	4 smaller
Standard	$(x-8)^2+(y-4)^2=16$	$(x-8)^2+(y-4)^2=9$	$(x-12)^2+y^2=16$	$(x-12)^2+y^2=9$
Function	$y=\sqrt{16-(x-8)^2}+4$ $y=-\sqrt{16-(x-8)^2}+4$	$y=\sqrt{9-(x-8)^2}+4$ $y=-\sqrt{9-(x-8)^2}+4$	$y=\sqrt{16-(x-12)^2}$ $y=-\sqrt{16-(x-12)^2}$	$y=\sqrt{9-(x-12)^2}$ $y=-\sqrt{9-(x-12)^2}$

Ring	5 larger	5 smaller
Standard	$y=\sqrt{16-(x-16)^2}+4$	$y=\sqrt{9-(x-16)^2}+4$
Function	$y=-\sqrt{16-(x-16)^2}+4$	$y=-\sqrt{9-(x-16)^2}+4$

CHALLENGE QUESTIONS

1. **What is the vertical speed of the skier when they reach the maximum height?**

   The skier attains a maximum height at the instant in time when the vertical speed is **zero**.

2. **Use your answer in question 1 to find the time t when the maximum height occurs.**

   To find this value of **t,** set the equation for the vertical speed equal to zero and solve for **t**. This is performed as follows. Solve the equation **$V(t) = -9.8\,t + 15 = 0$**. This gives **$t = 1.53$ seconds** as the time taken for the skier to reach maximum height.

3. **What is the maximum height reached by the skier, in metres?**

   The maximum height reached by the skier is found by calculating the displacement at the time given by question 2. This gives **$S(1.53) = 16.5$ m**. Thus, after leaving the ramp the skier attains a height of 16.5 m or 11.5 m above the edge of the ramp.

4. **If the displacement is zero when the skier reaches the ground, find the time t when they reach this point.**

   Set the displacement equation equal to zero. This gives **$S(t) = -4.9\,t^2 + 15\,t + 5 = 0$.** We observe that this involves solving a quadratic equation to find its real roots. Using the quadratic formula we obtain two roots. We reject the negative root and retain the positive root to give the time **t** for the skier to reach the ground. This gives a time **$t = 3.36$ seconds**. In other words it takes 3.36 seconds after the skier leaves the ramp for the skier to reach the ground.

5. **What is the vertical speed of the skier at the instant when they reach the ground?**

   The vertical speed of the skier at the point of impact with the ground is found by substituting the time found in question 4 into the velocity equation. This gives **$V(3.36) = -18.0$ m/s**. The vertical speed at the point of impact is negative because the skier is moving downward and we initially assumed that speeds measured upwards are positive.