STD 1: Measurement (Std 1), M1 Applications of Measurement (Y11)

Energy and Mass (Std 1)

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Exam Equivalent Time: 49.5 minutes *(based on HSC allocation of 1.5 minutes approx. per mark)*

IMPORTANT FEATURES AND TIPS FROM 2UG EXAM HISTORY

- *MS-M1 Energy and Mass* introduces some brand new content (calorie, joule and tonne units), as well as covering previous content such as electricity consumption (kilowatt hours) which was in the old Gen2 focus study "Resources".
- The syllabus documents provide excellent direction for question content and style in the new topic areas. This has been reflected in the database through supplementary questions written to beef up this deficit area.

ANALYSIS - Common pitfalls

- Electricity consumption questions have caused problems in the past, with sub-50% mean marks produced in 2013, 2014 and 2015!
- Students must understand the kWh unit as a concept and be prepared for a multi-step calculation that is prone to silly errors - a revision focus area.
- We expect a similar question style for calorie and joule questions. i.e. conversion competency and multi-step calculation requirement.

Questions

1. FS Resources, 2UG 2017 HSC 16 MC

The benchmark for annual greenhouse gas emissions from the residential sector is 3292 kg of carbon dioxide per person per year.

A new building, planned to house 6 people, has been designed to achieve a 25% reduction on this benchmark.

What is the maximum amount of carbon dioxide per year, to the nearest kilogram, that this building is designed to emit when fully occupied?

A. 823 kg

B. 2469 kg

C. 4938 kg

D. 14 814 kg

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2. Measurement, STD2 M1 SM-Bank 13 MC

The table shows the average energy used, in kilojoules per kilogram of body mass, by a person walking for 30 minutes at different speeds.

Walking speed	*Energy used in 30 minutes*
3 km/h	5.53 kJ/kg
5 km/h	7.37 kJ/kg

Rob, who weighs 90 kg, drinks a large cappuccino made with full cream milk. It contains 146 kilocalories.

For approximately how long must Rob walk at 3 km/hr to burn off the energy contained in the cappuccino? (1 kilocalorie)

A. 28 minutes

B. 37 minutes

C. 83 minutes

D. 110 minutes

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3. FS Resources, 2UG 2014 HSC 20 MC

RAP Data - Bottom 18%: School result (44%) was 5% above state average (39%)

In a household of 4, each member uses an average of 13 minutes of hot water per day.

The household uses a 9 kW hot water unit.

Electricity is charged at 11.97 c/kWh when the hot water unit is being used.

What is the electricity cost for the hot water used by this household in one week?

(A) $\$1.63$

(B) $\$6.54$

(C) $\$392.14$

(D) $\$653.56$

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4. FS Resources, 2UG 2017 HSC 26a

RAP Data - Bottom 12%: School result (100%) was 2% above state average (98%)

Electricity costs $0.27 per kWh.

How much does 20 kWh cost? ***(1 mark)***

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5. FS Resources, 2UG 2016 HSC 28b

The cost of buying a new heater is $990. It has an energy consumption of 505 kWh per year.

Energy is charged at the rate of $0.35 kWh.

How much will it cost in total to purchase and then run this heater for five years? ***(2 marks)***

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6. Measurement, STD2 M1 SM-Bank 03

A 225-watt television is turned on for an average of 4 hours per day during off-peak periods for a week.

If the television is not running at any other time and electricity is charged at $0.36/kWh during off-peak, how much does it cost to run the television for a week? ***(2 marks)***

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7. Measurement, STD2 M1 SM-Bank 08

A cannon ball is made out of steel and has a diameter of 23 cm.

(i) Find the volume of the sphere in cubic centimetres (correct to 1 decimal place). ***(2 marks)***

(ii) It is known that the mass of the steel used is 8.2 tonnes/m^3. Use this information to find the mass of the cannon ball to the nearest gram. ***(2 marks)***

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8. Measurement, 2UG 2018 HSC 28c

Every day, a 1200-watt microwave oven is used for 45 minutes at 40% power. Electricity is charged at $0.25 per kWh.

What is the cost of running this microwave oven for 180 days? ***(3 marks)***

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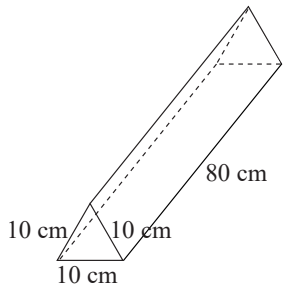
9. Measurement, STD2 M1 SM-Bank 04

Steel rods are manufactured in the shape a equilateral triangular prisms.



(i) Find the volume of the prism (answer correct to 1 decimal place). ***(2 marks)***

(ii) The mass of steel is 7850 kg/m^3. Use this information to find the mass of the steel rod correct to the nearest gram. ***(2 marks)***

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10. Measurement, STD2 M1 SM-Bank 07

Oscar and Nadine select a meal each from the table below.

Meal Choice	*Fat*	*Salt*	*Energy (Kilojoules)*
Pizza (3 slices)	30g	2500mg	4384
Hamburger	40g	1400mg	5050
BBQ Chicken	32g	1000mg	3120
Lamb Souvlaki	20g	NA	1872
Butter Chicken with Steamed rice	30g	NA	2827
Lemon Chicken and Fried rice	40g	NA	3611

Oscar has a hamburger and Nadine has the lamb souvlaki.

After dinner, Oscar goes for a run where he expends energy at 25 kJ/minute.

At the same time, Nadine goes for a brisk walk where she expends 12 kJ/minute.

Who will expend the kilojoule intake from their dinner the quickest, and by how many minutes? *(3 marks)*

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11. Measurement, STD2 M7 SM-Bank 01

Bikram runs a hot yoga studio.

If it costs 34 cents for 1-kilowatt (1000 watts) for 1 hour, how much does it cost him to run three 3200-watt heaters from 9:00 am to 12:30 pm on a single day? (Give your answer to the nearest cent)

(2 marks)

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12. Measurement, STD2 M1 SM-Bank 14

Cassius is a boxer and skips to keep fit.

The table below shows the average energy used, in kilojuoles per kilogram of body mass, by a person skipping for 10 minutes at different speeds.

Skipping speed	*Energy used in 10 minutes*
90 per minute	16.23 kJ/kg
150 per minute	24.18 kJ/kg

Cassius eats a hamburger that contains 550 kilocalories.

If Cassuis weighs 72 kilograms, how long must he skip at 150 skips per minute to burn off the energy contained in the hamburger? (1 kilocalorie = 4.184 kJ) Give your answer to 1 decimal place. *(3 marks)*

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13. FS Resources, 2UG 2013 HSC 26d

A section of Jim's electricity bill is shown.

Energy Used and Costs

METER ID	THIS READING	LAST READING	ENERGY USED	RATE (per kWh)	COST
Peak Energy Charge					
TMV04221/01	531.2	274.8	256.4 kWh	47.7700c	$122.48
Shoulder Energy Charge					
TMV04221/02	*A*	560.9	523.5 kWh	19.4000c	$101.56
Off-peak (Night) Energy Charge					
TMV04221/03	242.5	0.0	242.5 kWh	9.6000c	$23.28

(i) What is the value of A? *(1 mark)*

(ii) How much will Jim save if he uses 154 kWh of energy at the Off-peak rate rather than at the Peak rate? *(2 marks)*

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14. FS Resources, 2UG 2015 HSC 30a

The energy consumption of a computer in standby mode is 21 watts. The cost of electricity is 31 cents per kWh.

A school computer room has 20 computers.

How much will the school save by switching off all 20 computers during 11 weeks of school holidays? *(2 marks)*

Worked Solutions

1. FS Resources, 2UG 2017 HSC 16 MC

$$\begin{aligned}\text{Benchmark emissions} &= 6 \times 3292 \\ &= 19\ 752 \text{ kg}\end{aligned}$$

$$\begin{aligned}\therefore \text{ Max emissions of new building} &= 75\% \times 19\ 752 \\ &= 14\ 814 \text{ kg}\end{aligned}$$

$\Rightarrow$ D

2. Measurement, STD2 M1 SM-Bank 13 MC

$$\begin{aligned}\text{Kilojoules in cappuccino} &= 146 \times 4.184 \\ &= 610.864\end{aligned}$$

$$\begin{aligned}\therefore \text{ Time of the walk} &= \frac{610.864}{(90 \times 5.53)} \times 30 \\ &= 1.227\ldots \times 30 \\ &= 36.8\ldots \text{ minutes}\end{aligned}$$

$\Rightarrow$ B

3. FS Resources, 2UG 2014 HSC 20 MC

♦ *Mean mark 39%.*

$$\text{Usage per day} = 4 \times 13 = 52 \text{ mins}$$

$$\text{Usage per week} = 7 \times 52 = 364 \text{ mins}$$

Converting to kWh

$$\begin{aligned} &= (\text{hours of usage}) \times 9 \text{ kW} \\ &= \frac{364}{60} \times 9 \\ &= 54.6 \text{ kWh} \end{aligned}$$

$$\begin{aligned} \therefore \text{ Cost} &= 54.6 \times 11.97\text{c} \\ &\approx 654\text{c} \\ &\approx \$6.54 \end{aligned}$$

$$\Rightarrow B$$

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4. FS Resources, 2UG 2017 HSC 26a

$$\begin{aligned} \text{Cost} &= 20 \times \$0.27 \\ &= \$5.40 \end{aligned}$$

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5. FS Resources, 2UG 2016 HSC 28b

Cost to run heater for 5 years

$$\begin{aligned} &= 5 \times 505 \times 0.35 \\ &= \$883.75 \end{aligned}$$

$$\begin{aligned} \therefore \text{ Total purchase and running cost} \\ &= 883.75 + 990 \\ &= \$1873.75 \end{aligned}$$

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6. Measurement, STD2 M1 SM-Bank 03

Total electricity used

$$\begin{aligned} &= 7 \text{ days} \times 4 \text{ hours} \times 225 \\ &= 7000 \text{ watt hours} \\ &= 7 \text{ kWh} \end{aligned}$$

$$\begin{aligned} \therefore \text{ Running cost} &= 7 \times 0.36 \\ &= \$2.52 \end{aligned}$$

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7. Measurement, STD2 M1 SM-Bank 08

(i) $\text{Radius} = \dfrac{23}{2} = 11.5 \text{ cm}$

$$\begin{aligned} \text{Volume} &= \frac{4}{3}\pi r^3 \\ &= \frac{4}{3} \times \pi \times 11.5^3 \\ &= 6370.626\ldots \\ &= 6370.6 \text{ cm}^3 \text{ (to 1 d.p.)} \end{aligned}$$

(ii) Convert m^3 to cm^3:

$$\begin{aligned} 1 \text{ m}^3 &= 100 \text{ cm} \times 100 \text{ cm} \times 100 \text{ cm} \\ &= 1\,000\,000 \text{ cm}^3 \end{aligned}$$

Convert 8.2 tonnes to grams:

$$\begin{aligned} 8.2 \text{ tonnes} &= 8200 \text{ kg} \\ &= 8\,200\,000 \text{ g} \end{aligned}$$

$$\begin{aligned} \therefore \text{ Weight of cannon ball} \\ &= 6370.6 \times \frac{8\,200\,000}{1\,000\,000} \\ &= 52\,238.92 \\ &= 52\,239 \text{ grams} \end{aligned}$$

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8. Measurement, 2UG 2018 HSC 28c

$$\begin{aligned}\text{Daily usage} &= 1200 \times \frac{45}{60} \times 40\% \\ &= 360 \text{ watts}\end{aligned}$$

$$\begin{aligned}\text{180 day usage} &= 180 \times 360 \\ &= 64\,800 \text{ watts} \\ &= 64.8 \text{ kW}\end{aligned}$$

$$\begin{aligned}\therefore \text{ Cost over 180 days} &= 64.8 \times 0.25 \\ &= \$16.20\end{aligned}$$

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9. Measurement, STD2 M1 SM-Bank 04

(i) Area of triangular face (using sine rule)

$$\begin{aligned}&= \frac{1}{2} \times 10 \times 10 \times \sin 60^\circ \\ &= 43.301...\end{aligned}$$

$$\begin{aligned}\text{Volume} &= Ah \\ &= 43.301... \times 80 \\ &= 3464.10... \\ &= 3464.1 \text{ cm}^3 \text{ (to 1 d.p.)}\end{aligned}$$

(ii) Converting kg to g:

$$7850 \text{ kg} = 7\,850\,000 \text{ g}$$

Converting m^3 to cm^3:

$$\begin{aligned}1 \text{ m}^3 &= 100 \text{ cm} \times 100 \text{ cm} \times 100 \text{ cm} \\ &= 1\,000\,000 \text{ cm}^3\end{aligned}$$

$$\begin{aligned}\therefore \text{ Weight of steel rod} &= 3464.1 \times \frac{7\,850\,000}{1\,000\,000} \\ &= 27\,193.185 \\ &= 27\,193 \text{ g (nearest gram)}\end{aligned}$$

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10. Measurement, STD2 M1 SM-Bank 07

$$\text{Oscar's kJ intake} = 5050$$

$$\text{Time to work off} = \frac{5050}{25}$$
$$= 202 \text{ minutes}$$

$$\text{Nadine's intake} = 1872$$

$$\text{Time to work off} = \frac{1872}{12}$$
$$= 156 \text{ minutes}$$

$$202 - 156 = 46 \text{ minutes}$$

$\therefore$ Nadine will expend her dinner's kJ intake in 46 minutes less than Oscar.

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11. Measurement, STD2 M7 SM-Bank 01

$$\text{Total energy usage}$$
$$= 3 \times 3200 \times 3.5 \text{ hours}$$
$$= 33\,600 \text{ watts}$$

$$\therefore \text{ Cost} = \frac{33\,600}{1000} \times 0.34$$
$$= 11.424$$
$$= \$11.42 \quad \text{(nearest cent)}$$

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12. Measurement, STD2 M1 SM-Bank 14

$$\text{Kilojoules in hamburger}$$
$$= 550 \times 4.184$$
$$= 2301.2$$

$\therefore$ Skipping time to burn energy
$$= \frac{2301.2}{(72 \times 24.18)} \times 10$$
$$= 1.321\ldots \times 10$$
$$= 13.2 \text{ minutes} \quad \text{(to 1 d.p.)}$$

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13. FS Resources, 2UG 2013 HSC 26d

(i) $A =$ Last reading + Energy used
$$= 560.9 + 523.5$$
$$= 1084.4$$

♦ *Mean mark part (i) 43% and part (ii) 46%.*

(ii) $\text{Cost at off-peak} = 154 \times 9.6$
$$= 1478.4 \text{ cents}$$
$$\text{Cost at peak} = 154 \times 47.77$$
$$= 7356.58 \text{ cents}$$
$$\text{Saving} = 7356.58 - 1478.4$$
$$= 5878.18$$
$$= \$58.78 \quad \text{(nearest cent)}$$

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14. FS Resources, 2UG 2015 HSC 30a

21 watts usage per computer per hour.

Watts used by 20 computers in 11 weeks

$= 21 \times 20 \times 24 \times 7 \times 11$

$= 776\ 160$ watts

$= 776.16$ kW

$\therefore$ Cost of energy

$= 776.16 \times \$0.31$

$= \$240.6096$

$= \$240.61$ (nearest cent)

$\therefore$ The school will save \$240.61 by switching off all the computers.

♦ *Mean mark 49%.*