2022 AUSTRALIAN SCIENCE OLYMPIAD EXAM

PHYSICS_ANSWERS

Multiple choice questions:

1	**B**
2	**B**
3	**D**
4	**B**
5	**A**
6	**B**
7	**B**
8	**C**
9	**D**
10	**B**

1 mark for each question

Section B: Skateboarding (23 marks)

Part 1 (5 marks)

a.)

i)

0.5	Correct forces
0.5	Correct force direction

ii.

0.5	Correct forces
0.5	Correct force direction

b.)

0.5	Linear speed increase/decrease on ramps
0.5	Constant speed on flats

c.)

0.5	Correct potential energy curve shape (parabolic on ramps)
0.5	Correct kinetic energy curve shape (parabolic on ramps)
0.5	Correct total mechanical energy curve shape (straight line)
0.5	Kinetic + Potential = Total Mechanical Energy

Part 2 (10 marks)

a.)

0.5	Correct forces (normal, frictional, gravitational)
0.5	Correct force directions

b.)

0.5	Linear speed increase/decrease on ramps
0.5	Linear speed decrease on flat
1	All details correct: • Same gradient of speed decrease on flats • Speed when entering the next flat section is the same as leaving the previous flat section

c.)

1	No energy loss on ramps (flat line)
0.5	Parabolic energy decreases on flat surface
0.5	General curve proportion & shape is correct: • Energy loss on each flat is the same • 3 laps etc.

d.) Ans: 10.67 = 10 full laps

0.5	Correct total initial potential energy calculation

1.5	Correct calculation of work done on each lap
	• 0.75 mark: correct use of frictional formula
	• 0.75 mark: correct use of work formula
	• (1.5 mark alternative)
	  ○ 0.75 mark: correct use of frictional formula
	  ○ 0.75 mark: correct use of kinematic equations

0.5	Correct calculation of number of laps
0.5	Correct rounding of number of complete laps (only if correct value)

e.) Ans: 4.13m from the left.

1	Use of partial 'lap' to calculate distance travelled on the flat before stopping
1	Includes the ramp length (distance from origin)

Part 3 (8 marks)

a.) Ans: 9.67 laps = 9 full laps

0.5	Correct total initial potential energy calculation/initial velocity

2.5	Correct calculation of work done on each lap
	• (1 mark) Correctly takes into account angle increasing distance on rough surface
	• (1.5 mark alternative)
	  ○ 0.75 mark: correct use of frictional formula
	  ○ 0.75 mark: correct use of kinematic equations
	• (1.5 marks) Correct use of work equation
	  ○ 0.75 mark: correct use of frictional formula (0.25 for stating)
	  ○ 0.75 mark: correct use of work formula (0.25 for stating)

0.5	Correct calculation of number of laps
0.5	Correct rounding of number of complete laps (if correct number)

b.) Ans: 25.78m (must include vertical displacement on the ramp)

2	Correct calculation of vertical distance <u>on the rough surface</u> (without contribution from the ramp)
2max	Complete correct calculation of vertical distance including distance travelled on ramp • (0.5 mark) Identifies that the vertical distance on the ramp needs to be considered • (1 marks) Some attempt at calculation on the ramp, however incorrect • (2 marks) Complete correct calculation of the vertical distance

Section C: Satellite (15 marks)

1.) Correct Answer: 3.6 W

0.7	Value 3.6
0.3	Units W (only awarded if value correct)

2.) Correct Answer: 290K

0.7	Value 290
0.3	Units K (only awarded if value correct)

3.) (max 3)

0.5	Linearly increasing
0.5	Linear from 270K to 300K
1.0	Plot drawn correctly (axis labels, units, etc)
-0.5	Swapped hot/cold side
1.0	Correct explanation

4.) Correct answer: The temperature drop is greater across the aluminium. Noting that $\dot{Q} = k\,wt\,\Delta T/L$ and the dimensions of both plates are the same. To have the same heat flow through the aluminium and copper plates for a lower thermal conductivity the temperature drop needs to be greater.

0.5	Identify heat flow is equal on both plates
0.5	Identify only difference is thermal conductivity
0.5	Derive that for all else fixed ΔT inverse proportional to k.
0.5	Temperature drop is greater across Aluminium

5) Correct Answer: 1.26W

0.5	Identify that the total heat flow is in parallel
0.5	Heat flow for copper & aluminium plates
0.5	Total heat flow $\dot{Q} = 1.26$ W
0.5	Use $\Delta T = 3$

Q6)

1.0	Heat flow expressions for both Alice and Bob or correct argument that compares two heat flows.
1.0	Alice's setup is better (following proof).

Q7) (max 4)

1.5	Note connecting two branches is approximately an isotherm. Whereas a radial branch is a maximal thermal gradient
1.5	Note that heat flow is maximised for maximal thermal gradient and zero along thermal isotherm.
1.0	Bob's suggestion is better (with justification)

Section D: Lasers and Atoms (13 marks)

1a) 3 marks total

Marks	For
1	i) 449Hz
1	ii) 394Hz
1	iii) 420Hz

1b.) Correct answer: 285m/s

2	Correct formula used, accounting for reflection (-1 for no reflection)
1	Correct numerical input

2a.) Correct answers: 1.59eV, 1.56eV

2	Correct numerical answers
1	Answers in eV

2b.) Correct answer: Atom c) gives the correct frequency change which would result in the atom 'seeing' the laser as 780.0 nm. This corresponds to a horizontal velocity of around 115m/s. Note D) is travelling in the wrong direction to see the laser blue-shifted.

1	Recognition that only the x-component of the velocity is relevant
1	Correct use of light doppler formula, with some numerical calculation
1	Correctly uses red, rather than blue detuning/direction
1	Correct selection of atom

Section E: Unusual Physics (12 marks)

1.) 4 marks total

Marks	For
1	[a] = kg/s
1	[b] = kg/m^3
1	[c] = kgm^2/s
1	[d] = m^2

2.) 4 marks total

a.) 1 mark

Marks	For
0.5	A finite local maximum value of amplitude is reached
0.5	$A = F_0 / bf_0$

b.) 1 mark

Marks	For
0.5	The amplitude decreases as the frequency increases
0.5	A approaches 0 as f approaches infinity.

c.) 1 mark

Marks	For
0.5	A large finite value is reached
0.5	$A = F_0 / mf_0$

d.) 1 mark

Marks	For
0.5	Little impact on high frequencies or low frequencies
0.5	Will decrease shaking most in the region around $f = f_o$

3.)

a) 4 marks total

Marks	For
1	a = -2
1	b = 2
1	c = 1
1	d = 5

Half points awarded if students write down the set of simultaneous equations but cannot solve them.