HOLY CROSS COLLEGE

SEMESTER 1, 2016

Question/Answer Booklet

11 PHYSICS

Please place your student identification label in this box

SOLUTIONS

Student Name ____________________

Student's Teacher ____________________

Time allowed for this paper

Reading time before commencing work: 10 minutes
Working time for paper: 3 hours

Materials required/recommended for this paper

To be provided by the supervisor

This Question/Answer Booklet
Multiple-choice Answer Sheet
Data Sheet

To be provided by the candidate

Standard items: pens, pencils, eraser, correction fluid, ruler, highlighters

Special items: non-programmable calculators satisfying the conditions set by the School Curriculum and Standards Authority for this course

Important note to candidates

No other items may be taken into the examination room. It is **your** responsibility to ensure that you do not have any unauthorised notes or other items of a non-personal nature in the examination room. If you have any unauthorised material with you, hand it to the supervisor **before** reading any further.

Structure of this paper

Section	Number of questions available	Number of questions to be answered	Suggested working time (minutes)	Marks available	Percentage of exam
Section One: Short Answers	15	15	60	~~57~~ 65	40
Section Two: Problem-solving	6	6	90	~~64~~ 77	~~45~~ 48
Section Three: Comprehension	1	1	30	20	~~15~~ 12
				~~141~~ 162	100

Instructions to candidates

1. The rules for the conduct of examinations at Holy Cross College are detailed in the College Examination Policy. Sitting this examination implies that you agree to abide by these rules.

2. Write your answers in this Question/Answer Booklet.

3. Working or reasoning should be clearly shown when calculating or estimating answers.

4. You must be careful to confine your responses to the specific questions asked and to follow any instructions that are specific to a particular question.

5. Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.

   - Planning: If you use the spare pages for planning, indicate this clearly at the top of the page.
   - Continuing an answer: If you need to use the space to continue an answer, indicate in the original answer space where the answer is continued, i.e. give the page number. Fill in the number of the question(s) that you are continuing to answer at the top of the page.

6. Answers to questions involving calculations should be ***evaluated and given in decimal form.*** It is suggested that you quote all answers to ***three significant figures***, with the exception of questions for which estimates are required. Despite an incorrect final result, credit may be obtained for method and working, providing these are ***clearly and legibly set out***.

7. Questions containing the instruction *"**estimate**"* may give insufficient numerical data for their solution. Students should provide appropriate figures to enable an approximate solution to be obtained. Give final answers to a maximum of ***two significant figures*** and include appropriate units where applicable.

8. Note that when an answer is a vector quantity, it must be given with magnitude and direction.

9. In all calculations, units must be consistent throughout your working.

SECTION ONE: Short Answers

Marks Allotted: ~~56~~ 65 marks out of ~~141~~ 162 total.

Attempt ALL 15 questions in this section. Answers are to be written in the space below or next to each question.

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1. In terms of the energy of particles, explain why a sample of a volatile liquid, such as methylated spirits or acetone, cools as the liquid evaporates? **(4 marks)**

- Particles with high E_K leave the surface. (2)
- Average E_K of the liquid is reduced. (1)
- Temperature is less. (1)

2. Jane has been asked to give a short talk on sea breezes. Listed below are some key parts of her speech. Help her prepare the speech by choosing the best alternative for the options given.

In the following, indicate the answer by circling the best choice from the bolded options.

[½ mark each] **(4 marks)**

"During hot summer days, **[radiant/convective]** *energy from the sun heats the land and sea. The land, however, has a* **[lower/higher]** *specific heat capacity than the sea and soon has a* **[higher/lower]** *temperature than the water. The air near the ground becomes hot as a result of* **[convection/conduction]**. *As the air gets hot, it* **[contracts/expands]**, *becoming* **[less/more]** *dense than the air over the sea. The air over the* **[land/sea]** *rushes in towards the* **[sea/land]**, *replacing the rising warm air, causing what is know as a sea breeze."*

3. A student wishes to cool her 375 g soft drink (specific heat 3.50×10^3 $Jkg^{-1}K^{-1}$) from an initial temperature of 30.0 °C to a more pleasant 5.00 °C. What mass of ice at 0.00 °C should she add? **(4 marks)**

$$Q_{lost} = Q_{gained}$$

$$\Rightarrow m_d c_d \Delta T = m_i L_f + m_i c_w \Delta T \quad (1)$$

$$\Rightarrow (0.375)(3.50\times10^3)(30.0-5.00) = m_i(3.34\times10^5) + m_i(4.18\times10^3)(5.00-0) \quad (2)$$

$$\Rightarrow 3.281\times10^4 = 3.549\times10^5 \, m_i$$

$$\Rightarrow \underline{m_i = 0.0924 \text{ kg}}. \quad (1)$$

4. During a Myth Buster's programme investigating ballistics, a 1.75 g bullet is analysed by a high-speed video. It enters a pine board at a speed of 2.90×10^2 ms^{-1} and emerges out of the other side at 1.10×10^2 ms^{-1}. Calculate the work done by the board on the bullet. **(~~3~~ 4 marks)**

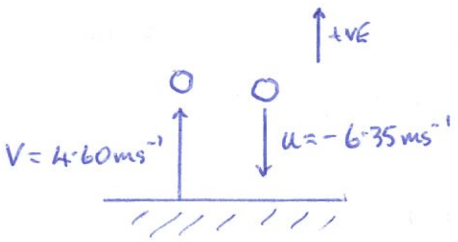
$$W = \Delta E_K = \tfrac{1}{2}mu^2 - \tfrac{1}{2}mv^2 \quad (1)$$

$$= \tfrac{1}{2}(1.75\times10^{-3})\left[(2.90\times10^2)^2 - (1.10\times10^2)^2\right] \quad (1)$$

(1)

$$= \underline{63.0 \text{ J}} \quad (1)$$

5. A golf ball of mass 45.0 g is dropped onto concrete, striking it at 6.35 ms^{-1} and rebounding at 4.60 ms^{-1}. Calculate the ball's change in momentum. **(4 marks)**



$\Delta v = v - u$

$= 4.60 - (-6.35)$ (1)

$= 10.95\ ms^{-1}$ up. (1)

$\Delta p = m\Delta v$

$= (0.0450)(10.95)$ (1)

$= \underline{0.493\ kg\,ms^{-1}\ up.}$ (1)

6. In playgrounds at McDonald and Hungry Jack's stores in Australia, recycled tyre rubber is used to cover the ground around and underneath the play equipment. Using sound Physics principles, explain why this is seen as a very good safety procedure. **(3 marks)**

- The force experienced is given by $F = \frac{\Delta p}{t}$ (1)
  $\Rightarrow F \propto \frac{1}{t}$
- Rubber is softer than the ground. (1)
- Time of impact increases.
  $\Rightarrow F$ is smaller. (1)

7. A student was asked to measure the diameter of a spherical steel ball in order to calculate its volume for a density calculation. She recorded the measurement as 1.2 ± 0.2 cm.

(a) Express the uncertainty as a ***percentage uncertainty***. **(2 marks)**

$$\% \text{ uncertainty} = \frac{0.2}{1.2} \times \frac{100}{1} \quad (1)$$

$$= \underline{16.7\,\%} \quad (1)$$

(b) Determine the volume of the steel sphere ($V = {}^4/_3\,\pi r^3$), expressing the answer with the appropriate significant figures and absolute error. **(~~3~~ 4 marks)**

$$V = \frac{4}{3}\pi r^3$$

$$= \frac{4}{3}\pi\left(\frac{1.2\times10^{-2}}{2}\right)^3 \quad (1)$$

$$= 9.0\times10^{-7}\ m^3 \pm 50\% \quad (1)$$

$$= 9.0\times10^{-7} \pm 4.5\times10^{-7}\ m^3 \quad (1)$$

[Sig. fig - 1 mark]

8. During an Olympic power-lifting event, Ryan manages to snatch 140.0 kg from the floor to 2.10 m above the floor (and over his head) in a total time of 1.80 s. Determine the average power generated by Ryan during this lift. **(3 marks)**

$$P = \frac{\Delta E_p}{t} = \frac{mg\Delta h}{t} \quad (1)$$

$$= \frac{(140.0)(9.80)(2.10)}{1.80} \quad (1)$$

$$= \underline{1.60\times10^3\ W} \quad (1)$$

9. (a) Just before she serves a ball in a tennis match, Serena Williams throws the ball towards the ground with an initial velocity of 5.00 ms^{-1}. If she releases the ball 0.800 m above the ground, with what velocity does it hit the ground? **(3 marks)**

$v = ?$

$u = 5.00 \text{ ms}^{-1}$

$a = 9.80 \text{ ms}^{-2}$

$t = ?$

$s = 0.800 \text{ m}$

$\downarrow$ +ve

$$v^2 = u^2 + 2as \quad (1)$$

$$= (5.00)^2 + 2(9.80)(0.800) \quad (1)$$

$$= 40.68$$

$$\Rightarrow \underline{v = 6.38 \text{ ms}^{-1} \text{ down}} \quad (1)$$

(b) If the ball has a mass of 57.0 g, how much energy does it have as it hits the ground? **(3 marks)**

$$E_T = E_K = \frac{1}{2}mv^2 \quad (1)$$

$$= \frac{1}{2}(0.0570)(6.38)^2 \quad (1)$$

$$= \underline{1.16 \text{ J}} \quad (1)$$

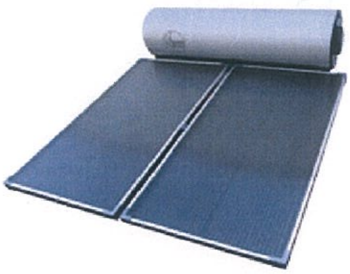
10. (a) Explain why heat transfer by conduction is more effective in liquids than in gases. **(2 marks)**

- Conduction relies on particles passing on energy by colliding with each other. (1)
- Particles are closer together in liquids so they conduct better than gases. (1)

(b) Explain why aluminium is a better conductor of heat than phosphorus, despite the fact that both are solids at room temperature and they have similar atomic masses. **(2 marks)**

- Metals like aluminium have free electrons that can transfer heat energy to neighbouring atoms. (1)
- Non-metals like phosphorus don't have free electrons so energy is transferred slower by the vibration of the atoms. (1)

11. Solar water heaters are popular in Perth. The intensity of the sun is approximately 8.00×10^2 Wm^{-2} and a typical heater would have an area of about 2.00 m^2. If the water was not circulating, calculate the temperature increase in 30.0 minutes if the mass of water in the pipes in the panel is 15.0 kg. **(4 marks)**



$$P = \frac{Q}{t}$$

$$\Rightarrow Q = (8.00 \times 10^2)(2.00)(30.0 \times 60.0) \quad (1)$$

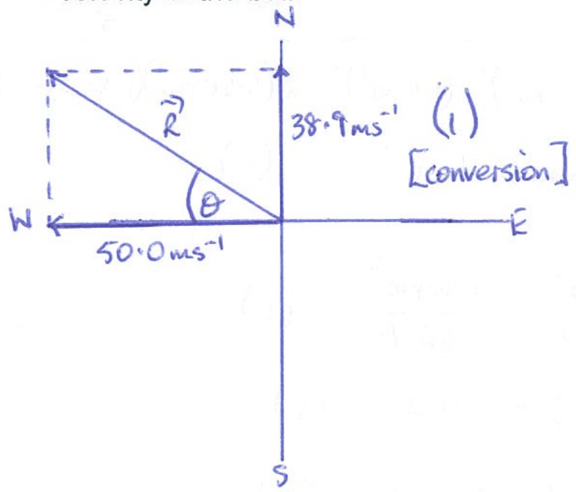
$$= 2.88 \times 10^6 \text{ J} \quad (1)$$

$$Q = m_w c_w \Delta T$$

$$\Rightarrow \Delta T = \frac{2.88 \times 10^6}{(15.0)(4.18 \times 10^3)} \quad (1)$$

$$= \underline{45.9\ ^\circ C} \quad (1)$$

12. A cricket ball moving at 1.40×10^2 kmh^{-1} south is struck by a batter and moves due west just after impact at 1.80×10^2 kmh^{-1}. Ignoring any frictional resistances, calculate the change in velocity of the ball. **(~~3~~ 6 marks)**



$\Delta v = v - u$

$= 50{\cdot}0\,ms^{-1}\,W - 38{\cdot}9\,ms^{-1}\,S$ (1)

$= 50{\cdot}0\,ms^{-1}\,W + 38{\cdot}9\,ms^{-1}\,N$ (1)

$\vec{R} = \sqrt{(50{\cdot}0)^2 + (38{\cdot}9)^2}$

$= 63{\cdot}4\,ms^{-1}$ (1)

$\tan\theta = \dfrac{38{\cdot}9}{50{\cdot}0}$

$\Rightarrow \theta = 37{\cdot}9^\circ$ (1)

$\therefore \vec{R} = 63{\cdot}4\,ms^{-1}\ W\,37{\cdot}9^\circ N$

(1)

13. Two bumper cars in an amusement park collide head-on. One has a mass of 4.50×10^2 kg and is moving at 4.50 ms^{-1}, while the other has a mass of 5.50×10^2 kg and is moving at 3.70 ms^{-1}. If the heavier vehicle rebounds at 0.500 ms^{-1}, calculate the final velocity of the lighter vehicle. **(~~3~~ 5 marks)**

Take direction of heavier vehicle as +ve.

$\Sigma p_i = \Sigma p_f$

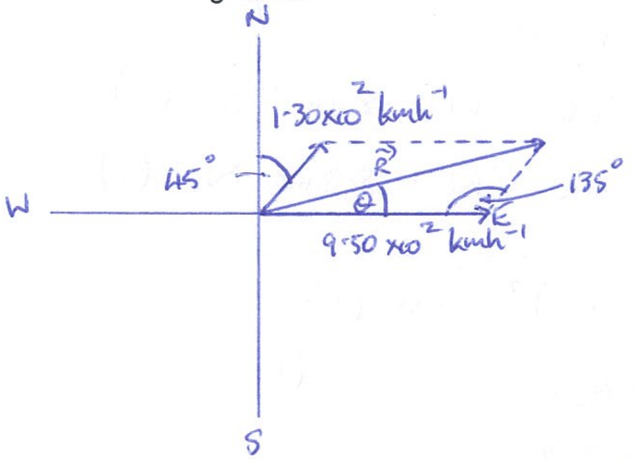
$\Rightarrow m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$ (1)

$\Rightarrow (4{\cdot}50\times10^2)(-4{\cdot}50) + (5{\cdot}50\times10^2)(3{\cdot}70) = (4{\cdot}50\times10^2)v_1 + (5{\cdot}50\times10^2)(-0{\cdot}500)$ (1)

(1) [sign conventions] $\Rightarrow$ $v_1 = 0{\cdot}633\,ms^{-1}$ in the original direction of the heavier car.

(1) (1) [direction]

14. A plane flying due east from Perth at 9.50×10^2 kmh^{-1} has to contend with a wind of 1.30×10^2 kmh^{-1} heading northeast. Determine its resultant velocity (***in kmh^{-1}***) over the ground. **(~~4~~ 5 marks)**



$$\vec{R} = \sqrt{(9{\cdot}50\times10^2)^2 + (1{\cdot}30\times10^2)^2 - 2(9{\cdot}50\times10^2)(1{\cdot}30\times10^2)\cos 135°} \quad (1)$$

$$= 1{\cdot}05 \times 10^3 \text{ kmh}^{-1} \quad (1)$$

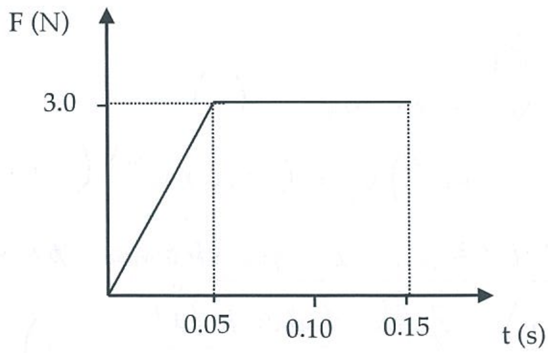
$$\frac{1{\cdot}05\times10^3}{\sin 135°} = \frac{1{\cdot}30\times10^2}{\sin\theta} \quad (1)$$

$$\Rightarrow \theta = 5{\cdot}02° \quad (1)$$

$$\therefore \underline{\vec{R} = 1{\cdot}05 \times 10^3 \text{ kmh}^{-1} \text{ E } 5{\cdot}02° \text{ N}}$$

(1)
[direction]

15. A force is applied to an object over a short period of time as shown in the graph below. Use the graph to determine the impulse acting on the object. **(3 marks)**



I = area under graph (1)

$= \frac{1}{2}(0{\cdot}05)(3{\cdot}0) + (0{\cdot}10)(3{\cdot}0)$ (1)

$=$ <u>0·38 Ns forwards</u>. (1)

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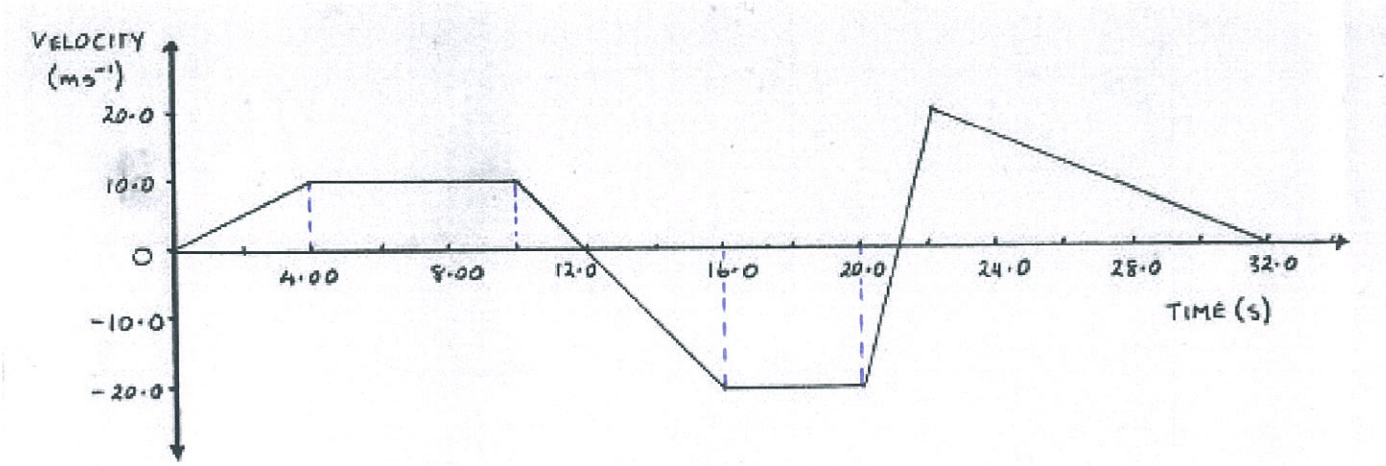
SECTION TWO: Problem Solving

Marks allotted: ~~64~~ 77 marks out of ~~141~~ 162 marks total.

Attempt ALL 6 questions in this section. The marks allocated to each question are given and the answers should be written in the spaces provided.

(~~10~~ 12 marks)

16. The motion of an object is represented in the graph below.



(a) Determine the total displacement of the object. **(5 marks)**

s = area under graph (1)

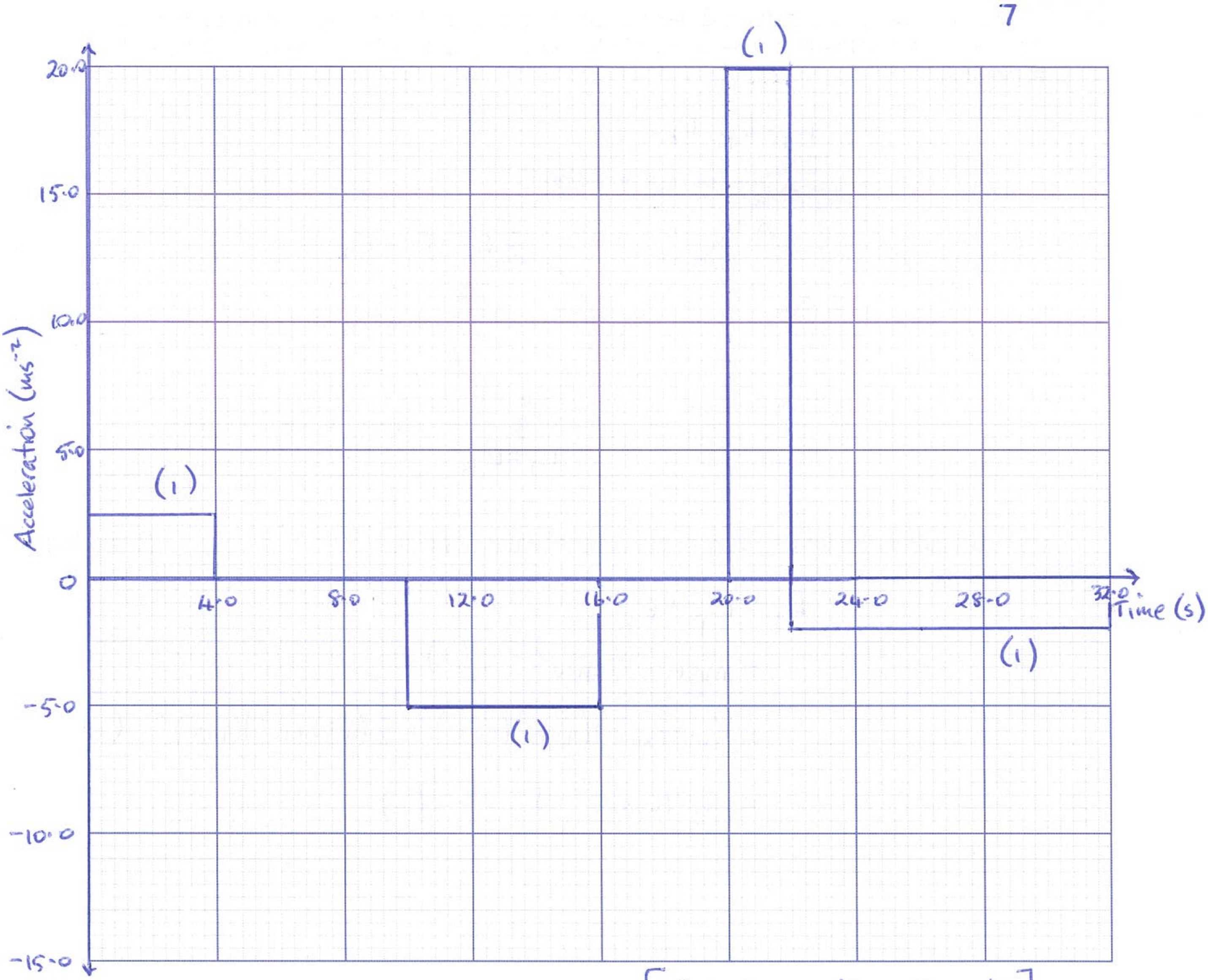
$= \frac{1}{2}(4.00)(10.0) + (6.00)(10.0) + \frac{1}{2}(2.0)(10.0) + \frac{1}{2}(4.0)(-20.0)$

$+ (4.0)(-20.0) + \frac{1}{2}(1.0)(-20.0) + \frac{1}{2}(11.0)(20.0)$ (3)

$=$ 70.0 m forwards (1)

(b) Draw an acceleration – time graph of this motion, giving ***clear scales*** on each axis.

(~~5~~ 7 marks)



[Labels + units - 2 marks
Shape - 1 mark]

$a_1 = \frac{10.0 - 0}{(4.0 - 0)}$
$= 2.50 ms^{-2}$

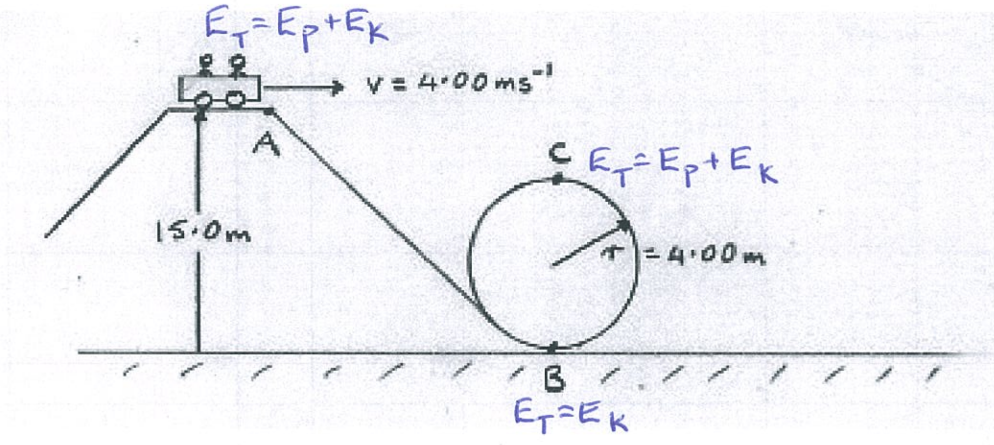
$a_2 = \frac{-20.0 - 10.0}{(16.0 - 10.0)}$
$= -5.00 ms^{-2}$

$a_3 = \frac{20.0 - (-20.0)}{(22.0 - 20.0)}$
$= 20.0 ms^{-2}$

$a_4 = \frac{0 - 20.0}{(32.0 - 22.0)}$
$= -2.00 ms^{-2}$

~~(11~~ 12 marks)

17. "The Boomerang" is a roller coaster ride at Knott's Berry Farm amusement park in Los Angeles. Part of the ride is as shown below with a 4.32×10^3 kg coaster moving at $4.00\ ms^{-1}$ at point A.



(a) Calculate the total energy of the roller coaster at point A. **(3 marks)**

$$E_T = E_p + E_K$$
$$= mgh + \tfrac{1}{2}mv^2 \quad (1)$$
$$= (4.32\times10^3)(9.80)(15.0) + \tfrac{1}{2}(4.32\times10^3)(4.00)^2 \quad (1)$$
$$= \underline{6.70\times10^5\ J} \quad (1)$$

(b) How fast is the coaster travelling at point B? **(3 marks)**

$$E_T = E_K = \tfrac{1}{2}mv^2 \quad (1)$$
$$\Rightarrow 6.70\times10^5 = \tfrac{1}{2}(4.32\times10^3)v^2 \quad (1)$$
$$\Rightarrow \underline{v = 17.6\ ms^{-1}} \quad (1)$$

(c) Theoretically, the minimum speed required to safely make it through point C is 10.3 ms^{-1}. Assuming that the designers of the ride have built in a "safety margin", determine:

(i) the speed at point C. 4 ~~(3~~ **marks)**

$$E_T = E_p + E_K$$

$$= mgh + \frac{1}{2}mv^2 \quad (1) \quad (1)$$

$$\Rightarrow 6.70\times10^5 = (4.32\times10^3)(9.80)(8.00) + \frac{1}{2}(4.32\times10^3)v^2 \quad (1)$$

$$\Rightarrow \underline{v = 12.4 \text{ ms}^{-1}} \quad (1)$$

(ii) the safety margin built in, expressing the answer as a percentage. **(2 marks)**

$$\text{Safety margin} = \frac{(12.4-10.3)}{10.3} \times \frac{100}{1} \quad (1)$$

$$= 20.4\% \quad (1)$$

12
(~~10~~ marks)

18. In a laboratory investigation, a group of students applied forces of differing sizes onto an object. Each force was applied for a time of 1.20 s. The students measured the change in velocity of the object for each trial. The results are given below.

Force (N)	Change in Velocity (ms^{-1})
0	0
1.6	1.8
3.1	3.5
4.9	5.8
7.8	8.9
11.3	13.0
15.4	17.5

(a) Graph these results on the graph paper provided. Draw the line of best fit. (HINT: Graph "change in velocity" on the x-axis.) **(4 marks)**

(b) Calculate the gradient of the line of best fit. **(~~3~~ marks)** 4

$$\text{gradient} = \frac{(17.6 - 0.0)}{(20.0 - 0.0)} \quad (1)$$

$$= 0.880 \ \text{N m}^{-1}\text{s} \ (\text{kg s}^{-1})$$

(1) (1)

[sig fig - 1 mark]

(c) Use the gradient to determine the mass of the object. **(~~3~~ marks)** 4

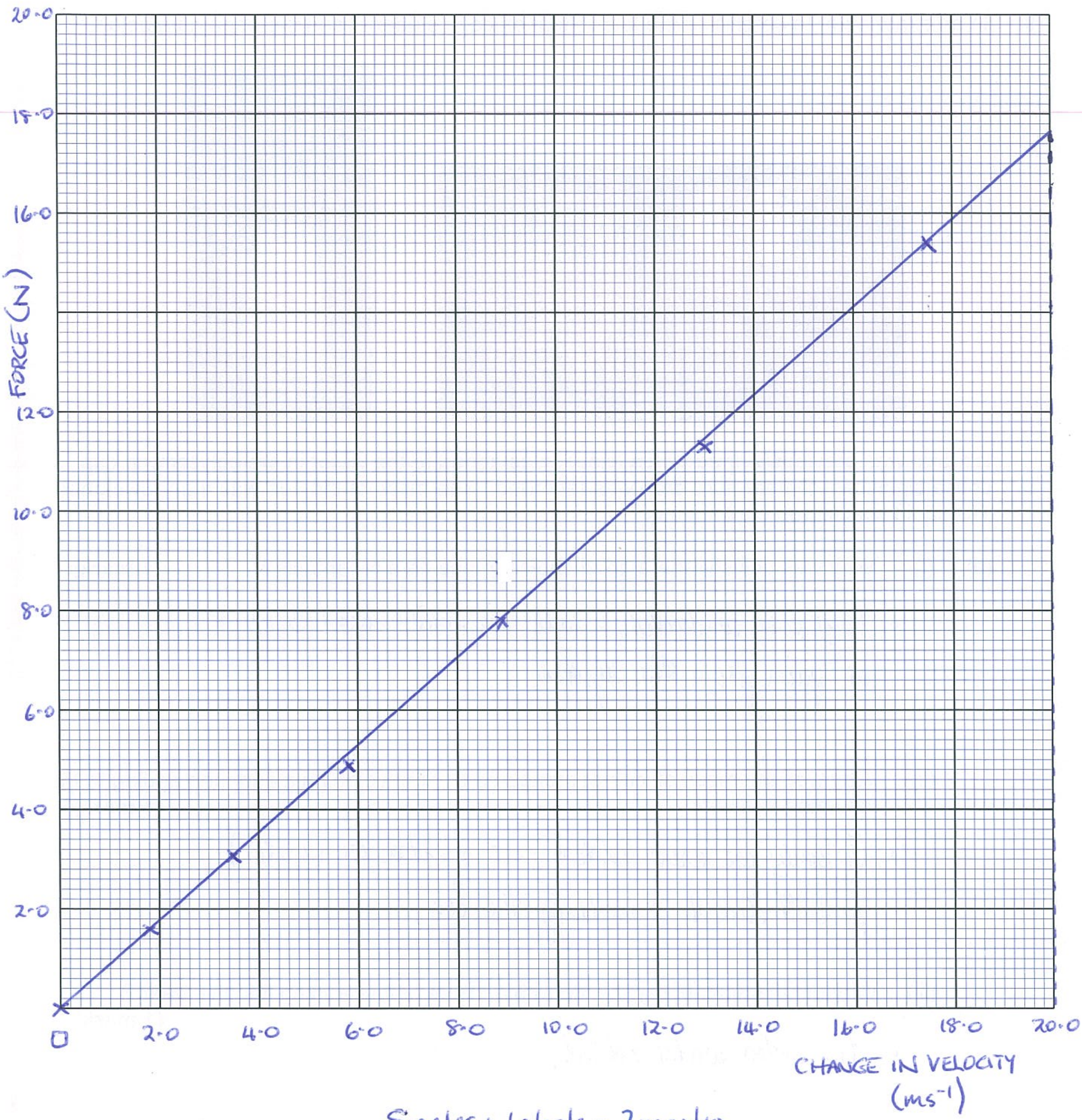
$$F = \frac{m\Delta v}{t}$$

$$\Rightarrow \text{gradient} = \frac{F}{\Delta v} = \frac{m}{t} \quad (1)$$

$$\Rightarrow m = \text{gradient} \times t \quad (1)$$

$$= (0.880)(1.20) \quad (1)$$

$$= 1.06 \text{ kg} \quad (1)$$



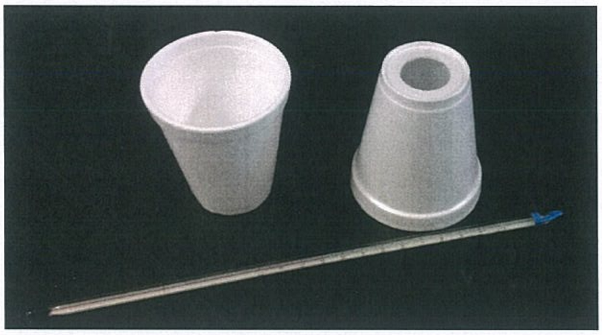
Scales + labels - 2 marks

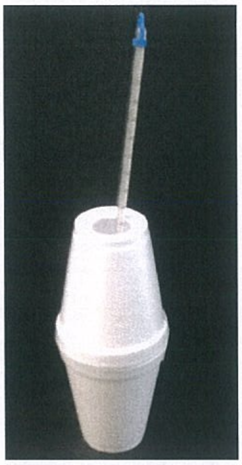
Plotting - 1 mark

Line of best fit - 1 mark.

(~~13~~ 14 marks)

19. In an experiment to determine the latent heat of ice, a student used the apparatus below.





Ice, that was previously dried with a tissue, was added to the water in the polystyrene cup until a significant temperature drop was recorded. The mass of the cup was then reweighed. The liquid was stirred continuously.

(a) (i) Why was polystyrene a good choice to use as a receptacle? **(1 mark)**

- Very poor conductor – will minimise heat loss or gain from the system.

(ii) Why was the mass of ice not measured by first weighing it and then adding to the insulated beaker? **(1 mark)**

- Only ice was added – no melted ice (water) present due to handling the ice.

(iii) Why did the student dry the ice with a tissue before adding it to the water? **(1 mark)**

- No extra water added.

(b) If room temperature was 25.0 °C, why was starting the experiment at 40.0 °C and concluding at approximately 10.0 °C a good experimental technique? **(2 marks)**

- Initial heat loss is due to the ice rather than the heat from the outside. (1)
- Also balances heat coming in from the outside when the liquid is below room temperature. (1)

The student tabulated the following results:

Mass of water before adding the ice (g)	100.0
Mass of water after adding ice (g)	135.0
Initial temperature (^{0}C)	40.0
Final temperature after adding the ice (^{0}C)	10.0
Mass of ice (g)	35.0

(c) Using the student's data, calculate the latent heat of ice. **(6 marks)**

$$Q_{lost} = Q_{gained}$$

[ΔT values - 1 mark]

$$\Rightarrow m_w c_w \Delta T = m_i L_f + m_i c_w \Delta T \quad (2)$$

$$\Rightarrow (0.100)(4.18\times10^3)(40.0-10.0) = (0.0350) L_f + (0.0350)(4.18\times10^3)(10.0-0.0) \quad (1)$$

$$\Rightarrow 1.254\times10^4 = 0.0350 L_f + 1.463\times10^3$$

$$\Rightarrow \underline{L_f = 3.16\times10^5 \text{ J kg}^{-1}} \quad (1)$$

[Sig fig - 1 mark]

(d) Determine the percentage error between your value and the accepted value of 3.34×10^5 Jkg^{-1} and comment on the accuracy and techniques the student used.
(~~2~~ 3 marks)

$$\% \text{ error} = \frac{(3.34\times10^5 - 3.16\times10^5)}{3.34\times10^5} \times \frac{100}{1} \quad (1)$$

$$= 5.39\% \quad (1)$$

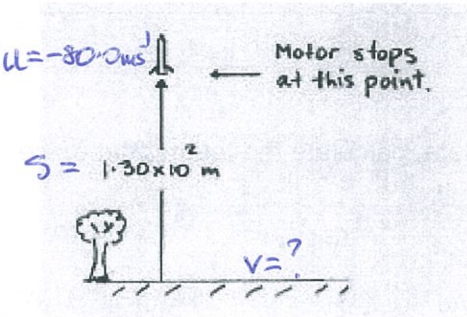
$\therefore$ Result is quite accurate.

$\Rightarrow$ Student techniques were very good. (1)

20
(~~14~~ marks)

20. A 0.120 kg rocket accelerates rapidly from rest up to a height of 1.30 x 10^2 m where the "motor" cuts out. Its speed is 80.0 ms^{-1} at this point. After this point, the rocket continues to rise under the influence of gravity to a maximum height before falling back to earth. No parachute or streamer is deployed to slow its decent.

↓+ve



(a) Calculate the maximum height reached by the rocket. (Hint: Consider the movement from the point where the rocket motor stops).

↓+ve Consider movement to the top. (~~3~~ marks) 6

$v = 0.0\ ms^{-1}$

$u = -80.0\ ms^{-1}$ (1)

$a = 9.80\ ms^{-2}$

$t = ?$

$s = ?$

$v^2 = u^2 + 2as$

$\Rightarrow s = \frac{v^2 - u^2}{2a}$ (1)

$= \frac{0 - (-80.0)^2}{2(9.80)}$ (1)

$= -3.26 \times 10^2\ m$ (1)

$\therefore$ Height $= 3.26 \times 10^2 + 1.30 \times 10^2$ (1)

$= \underline{4.56 \times 10^2\ m}$ above the ground. (1)

(b) Theoretically, how long is the rocket in flight from the point where the motor stops?

↓+ve Consider the whole motion. (~~3~~ marks) 4

$v = ?$

$u = -80.0\ ms^{-1}$

$a = 9.80\ ms^{-2}$

$t = ?$

$s = 1.30 \times 10^2\ m$

$v^2 = u^2 + 2as$

$= (-80.0)^2 + 2(9.80)(1.30 \times 10^2)$ (1)

$= 8.948 \times 10^3$

$\Rightarrow v = 94.6\ ms^{-1}$ (1)

$v = u + at$

$\Rightarrow t = \frac{v - u}{a} = \frac{94.6 - (-80.0)}{9.80} = \underline{17.8\ s}$ (1)

(1)

(c) Theoretically, what is the impact velocity with the ground? **(3 marks)**

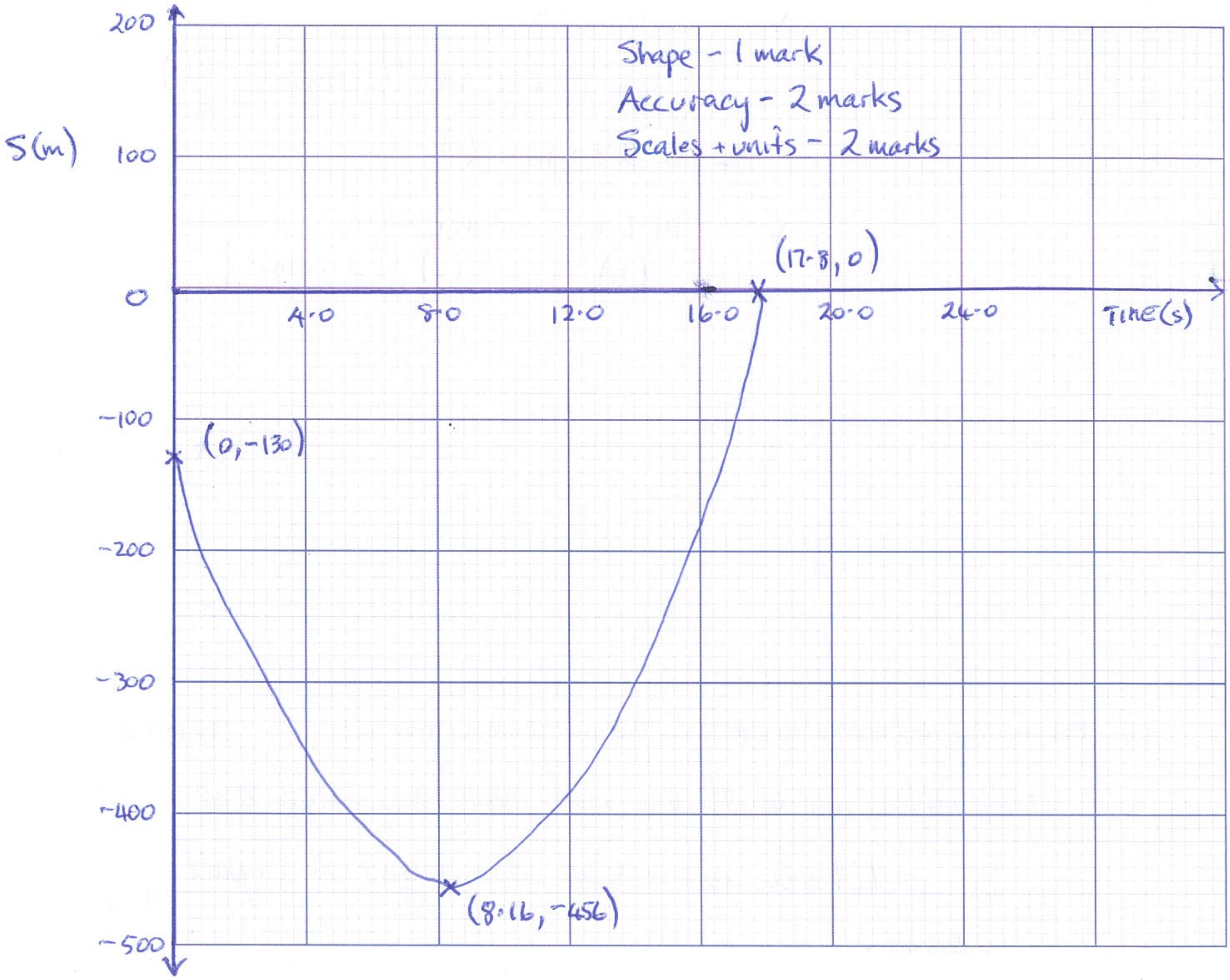
$$v^2 = u^2 + 2as$$
$$= (-80.0)^2 + 2(9.80)(1.30\times10^2) \quad (1)$$
$$= 8.948\times10^3 \quad (1)$$
$$\Rightarrow v = 94.6\ ms^{-1} \text{ down}$$
(1)

(d) Explain why your answer to part (c) is "theoretical" rather than "real". **(2 marks)**

- Friction due to the air will cause an energy loss. (1)
- The rocket will not achieve this height or impact velocity. (1)

(e) Draw a displacement-time graph for the motion of the rocket after the rocket motor stops. Include ***clear scales*** on each axis. (Take t = 0 when the rocket motor stops.)

(~~3~~ 5 marks)



To calculate time to top. ↓ +ve

$v = 0.0 \text{ ms}^{-1}$

$u = -80.0 \text{ ms}^{-1}$

$a = 9.80 \text{ ms}^{-2}$

$t = ?$

$s = ?$

$v = u + at$

$\Rightarrow t = \frac{v - u}{a}$

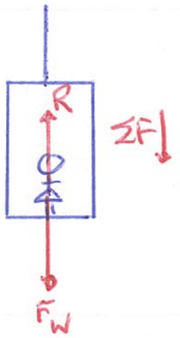
$= \frac{0 - (-80.0)}{9.80}$

$= 8.16 \text{ s}.$

7
(~~6~~ marks)

21. A 70.0 kg person is in a lift that is stationary at the thirtieth floor of a building. The lift uniformly accelerates downwards at 1.75 ms^{-2} for 3.00 s before maintaining its speed. As it nears the ground floor, the lift decelerates uniformly at 2.00 ms^{-2} to bring the lift to a stop.

(a) What is the apparent weight of the person as the lift starts to move down from the thirtieth floor? **(~~3~~ marks)**
4



$$\Sigma F = F_W - R \quad (1)$$
$$\Rightarrow R = F_W - \Sigma F$$
$$= mg - ma \quad (1)$$
$$= (70.0)(9.80 - 1.75) \quad (1)$$
$$= 5.635 \times 10^2 \text{ N}$$
$$\therefore \underline{\text{Apparent weight} = 5.64 \times 10^2 \text{ N}} \quad (1)$$

(b) Determine the apparent weight when the lift is moving downwards with a constant speed. **(3 marks)**

At constant speed, $\Sigma F = 0$

$$\Rightarrow R = F_W \quad (1)$$
$$= mg$$
$$= (70.0)(9.80) \quad (1)$$
$$= 6.86 \times 10^2 \text{ N}$$
$$\therefore \underline{\text{Apparent weight} = 6.86 \times 10^2 \text{ N}} \quad (1)$$

SECTION C: Comprehension and Interpretation

Marks Allotted: 20 marks out of ~~141~~ 162 marks total.

Read the passage carefully and answer all of the questions at the end. Candidates are reminded of the need for correct English and clear and concise presentation of answers. Diagrams (sketches), equations and/or numerical results should be included where appropriate.

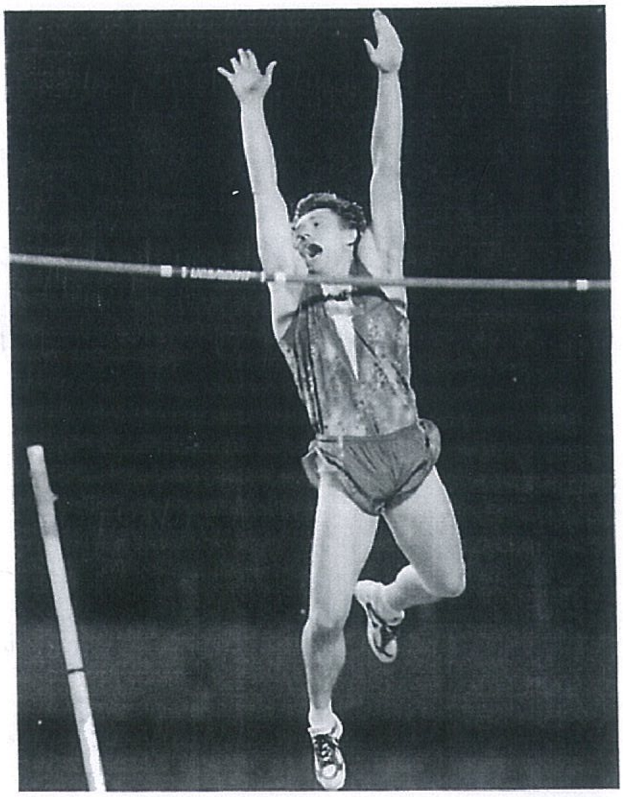
Pole vaulting can be seen as a series of stages.

- **Run up** - pole carried horizontally.
- **Going up** - pole flexed.
- **Top** - body over bar, pole straight.
- **Coming down** - pole falling away.
- **Landing** on large cushioned landing pad - pressed down by body.

JUBILATION IN JUBAKALAND

Last night after more than four hours, during which time he jumped just four times, Sergey Bubka of the Soviet Union became world pole vault champion yet again. He was winner at both previous World Championships and at the 1988 Olympics. He was probably the hottest favourite of the week; even his rivals said they had no chance. But with the bar set at 5.95 m - well over the height of a double-decker bus - Bubka faced a moment of crisis. The 22-year-old Hungarian, Istvan Bagyula, winner at the World Student Games, was already over at 5.90. Bubka had failed once at that level and, having opted not to have another jump in that round, failed again at 5.95. So this was his final chance. It looked tense enough from the stands. But what Bubka knew, and no one else did, was that he was in agony from an injured heel on which he had already had two pain-killing injections. He ran forward, shifted the pole into the jousting position, gathered speed, took off and indeed flew over the bar, probably clearing it by about a foot.

Bagyula had no chance at 5.95 m. Bubka stuck his injured foot in an icebag and declined to raise the bar to have a crack at the record, which he raised to 6.10 m in Malmo earlier this month - a significant figure because it broke what pre-metric athletes would have called the 20-foot barrier had they ever contemplated the possibility of man even approaching such a thing. No one else has yet got close.



Bubka's dominance bewilders even his opponents: the explanation (if I correctly interpret the American Tim Bright, who came sixth) appears to be that he can work up a faster take-off speed than anyone else, which enables him to use a more rigid pole which gives him more lift.

22. (a) Describe the energy changes that are occurring during each stage of the pole vault. **(5 marks)**

Run up - increasing E_K on run; (1)

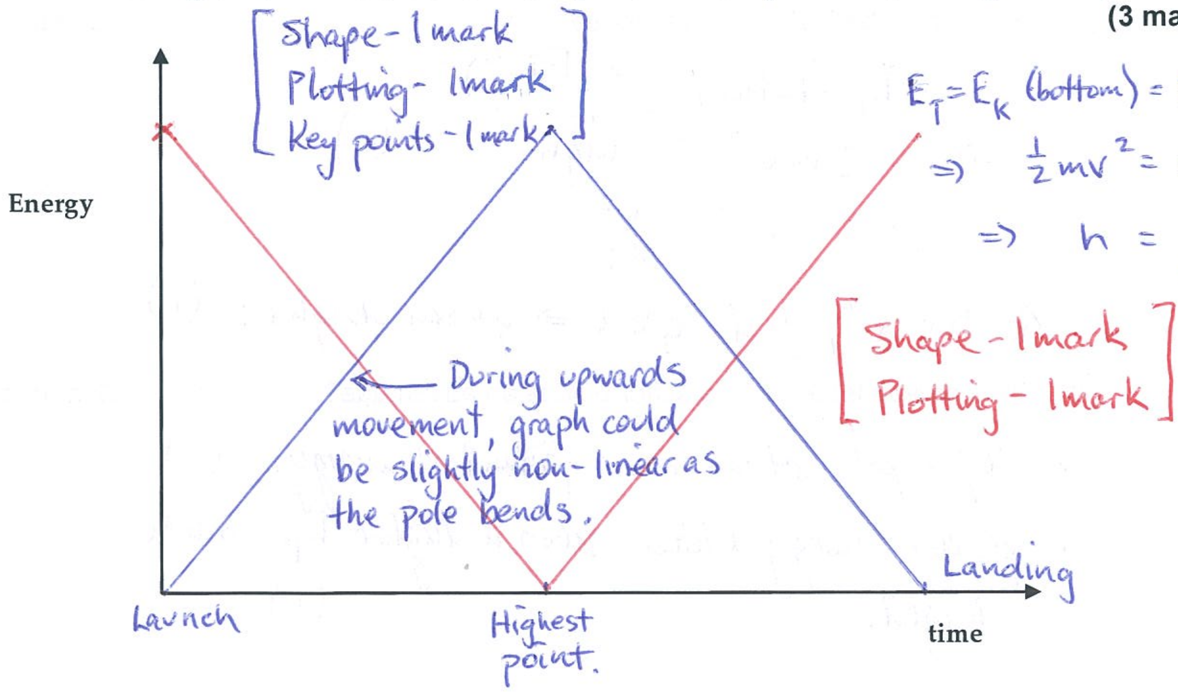
Going up - E_p stored in pole as it bends; releases energy as E_p and E_K as the athlete rises. (1)

Top - max. E_p achieved. (1)

Coming down - E_p becomes E_K. (1)

Landing - E_K becomes E_p as the bag deforms. (1)

(b) Sketch a graph to illustrate how the pole-vaulter's potential energy changes with time during the pole vault. Mark on the position of the pole-vaulter at significant points. **(3 marks)**



$E_T = E_K (\text{bottom}) = E_p (\text{top})$

$\Rightarrow \frac{1}{2}mv^2 = mgh$

$\Rightarrow h = \frac{v^2}{2g}$

(c) On the same graph, show how the pole-vaulter's kinetic energy changes with time. **(2 marks)**

(d) ***Estimate*** the maximum potential energy that Bubka gains during the world record vault. **(3 marks)**

Assume Bubka is 100 kg. (1)

$E_p = mgh$

$= (100)(9.80)(6.10)$ (1)

$= \underline{6.0 \times 10^3 \text{ J}}$ (1)

(e) (i) Do you think his maximum kinetic energy would be greater or less than this? **(1 mark)**

Greater.

(ii) Explain your answer, considering conservation of energy. **(2 marks)**

- Energy is lost due to sound and heat as the pole bends.
- Air resistance will decrease his height very slightly.
- Energy is lost in the pole as it unbends.

[Any 2 reasonable points - 1mark each].

~~(g)~~ f) In the article, the comment is made that the champion pole-vaulter achieves a much faster take-off speed than his rivals and this means that he can use a much stiffer pole.

(i) How does the faster take-off speed help? **(2 marks)**

$E_K \text{ (bottom)} = E_p \text{ (top)}$

$\Rightarrow \frac{1}{2}mv^2 = mgh$ (1)

$\Rightarrow h = \frac{v^2}{2g}$

As $h \propto v^2$, faster speed $\Rightarrow$ greater height. (1)

(ii) Why do you think using a stiffer pole is an advantage? **(2 marks)**

- Stiffer pole stores more potential energy. (1)
- Greater energy release gives a higher E_p - more height. (1)

END OF EXAMINATION

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