Western Australian Certificate of Education
ATAR course examination, 2019

Question/Answer Booklet

11 PHYSICS

Test 2 - Forces and Energy

Name SOLUTIONS

Student Number: In figures

Mark: $\overline{32}$ In words

Time allowed for this paper

Reading time before commencing work: five minutes
Working time for paper: fifty minutes

Materials required/recommended for this paper

To be provided by the supervisor

This Question/Answer Booklet
Formulae and Data Booklet

To be provided by the candidate

Standard items: pens, (blue/black preferred), pencils (including coloured), sharpener, correction fluid/tape, eraser, 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					
Section Two: Problem-solving	6	6	50	35	100
Section Three: Comprehension					
				Total	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.

1. A person's car battery has run flat. In an attempt to "jump start" the car, another person tries to push it along a level driveway while the driver tries to start it.

(a) Why is it so hard or difficult to start the car moving? (2 marks)

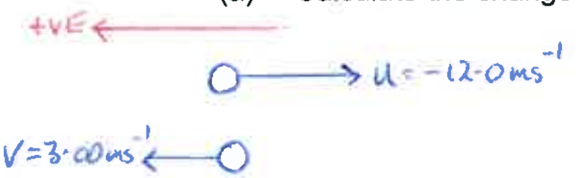
- The car has a large mass. (1)
- Hence it has a large inertia, requiring a large force to overcome it. (1)

(b) It becomes easier to move the car once it is rolling. Why is this? (2 marks)

- Once moving, the car has large inertia and wants to keep moving. (1)
- Much less force is required to keep it moving. (1)

2. A charged drop of oil (mass = 3.30 x 10^{-3} g) is moving at a velocity of 12.0 ms^{-1} in an experimental chamber. It then experiences a retarding force for 2.00 x 10^{-3} s, causing it to move at 3.00 ms^{-1} in the opposite direction.

(a) Calculate the change in velocity of the oil drop. (2 marks)



$\Delta v = v - u$

$= 3.00 - (-12.0)$ (1)

$= 15.0\,ms^{-1}$ backwards (1)

(b) Determine the force that acted during this short time. (3 marks)

$I = Ft = m\Delta v = \Delta p$

$\Rightarrow \quad F = \dfrac{m\Delta v}{t}$ (1)

$= \dfrac{(3.30 \times 10^{-6})(15.0)}{(2.00 \times 10^{-3})}$ (1)

$= \underline{2.47 \times 10^{-2} \text{ N backwards}}$ (1)

(c) What impulse acted on the oil drop? (2 marks)

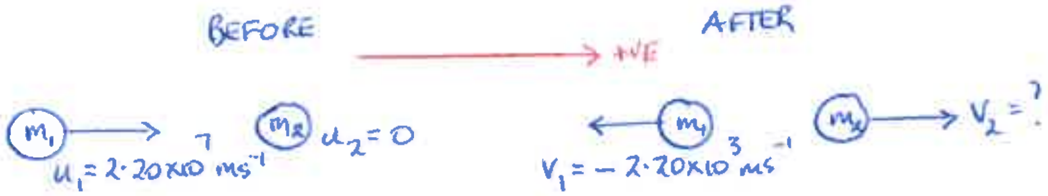
$I = Ft$

$= (2.47 \times 10^{-2})(2.00 \times 10^{-3})$ (1)

$= \underline{4.94 \times 10^{-5} \text{ Ns backwards}}$ (1)

3. A fast neutron of mass 1.67×10^{-27} kg travels at 2.20×10^{7} ms^{-1} in a nuclear reactor. It collides with a stationary deuterium atom of mass 3.34×10^{-27} kg and bounces backwards along its path at 2.20×10^{3} ms^{-1}.

(a) Calculate the final velocity of the deuterium atom. (3 marks)



$$\Sigma p_i = \Sigma p_f$$

$$\Rightarrow m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2 \quad (1)$$

$$\Rightarrow (1.67 \times 10^{-27})(2.20 \times 10^{7}) + 0 = (1.67 \times 10^{-27})(-2.20 \times 10^{3}) + (3.34 \times 10^{-27}) v_2 \quad (1)$$

$$\Rightarrow \underline{v_2 = 1.10 \times 10^{7} \text{ ms}^{-1} \text{ forwards}} \quad (1)$$

(b) Use calculations to determine if the collision is elastic. (3 marks)

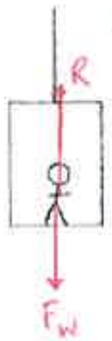
$$\Sigma E_K(\text{initial}) = \tfrac{1}{2} m_1 u_1^2 + \tfrac{1}{2} m_2 u_2^2$$
$$= \tfrac{1}{2}(1.67 \times 10^{-27})(2.20 \times 10^{7})^2 + 0$$
$$= 4.04 \times 10^{-13} \text{ J} \quad (1)$$

$$\Sigma E_K(\text{final}) = \tfrac{1}{2} m_1 v_1^2 + \tfrac{1}{2} m_2 v_2^2$$
$$= \tfrac{1}{2}(1.67 \times 10^{-27})(2.20 \times 10^{7})^2 + \tfrac{1}{2}(3.34 \times 10^{-27})(1.10 \times 10^{7})^2$$
$$= 6.06 \times 10^{-13} \quad (1)$$

$\therefore$ Collision is inelastic. (1)

4. A person of mass 80.0 kg is standing in a lift in an office tower. Calculate his apparent weight when:

(a) the lift is moving upwards at a constant velocity. (2 marks)



$a = 0\ ms^{-2}$

$$\Sigma F = 0$$

$$\Rightarrow R = F_W \quad (1)$$

$$= (80.0)(9.80)$$

$$= \underline{784\ N} \quad (1)$$

(b) the lift is decelerating to a stop at 1.70 ms^{-2} when it nears the twentieth floor of the building, having risen up from the ground floor. (3 marks)

$\Sigma F \downarrow \quad a \downarrow$

$$\Sigma F = F_W - R$$

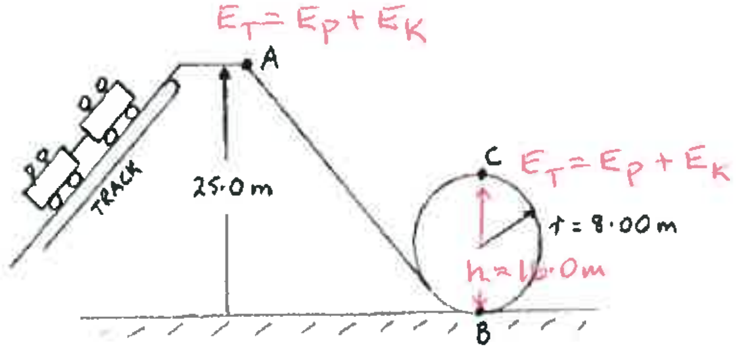
$$\Rightarrow R = F_W - \Sigma F \quad (1)$$

$$= mg - ma$$

$$= (80.0)(9.80 - 1.70) \quad (1)$$

$$= \underline{648\ N} \quad (1)$$

5. A roller coaster of total mass 8.73 x 10^3 kg is pulled by a mechanical track up to the top part of the track as shown below. It takes 22.0 seconds to reach point A, where it is moving at 2.00 ms^{-1}.



(a) Calculate the total energy of the roller coaster if it is moving at a speed of 2.00 ms^{-1} at point A. (3 marks)

$$E_T = E_P + E_K$$
$$= mgh + \frac{1}{2}mv^2 \quad (1)$$
$$= (8.73\times10^3)(9.80)(25.0) + \frac{1}{2}(8.73\times10^3)(2.00)^2 \quad (1)$$
$$= \underline{2.16\times10^6\ J} \quad (1)$$

(b) What is the average power of the motor used to pull the roller coaster up to point A? If you could not calculate a value for part (a), use E_t = 2.20 x 10^6 J. (2 marks)

$$P = \frac{\Delta E_T}{t}$$
$$= \frac{2.16\times10^6}{22.0} \quad (1)$$
$$= \underline{9.82\times10^4\ W} \quad (1)$$

(c) How fast would the roller coaster travel at point C? (3 marks)

$E_T = E_p + E_K = mgh + \frac{1}{2}mv^2$ (1)

$\Rightarrow 2.16 \times 10^6 = (8.73 \times 10^3)(9.80)(16.0) + \frac{1}{2}(8.73 \times 10^3)v^2$ (1)

$\Rightarrow \underline{v = 13.5\ ms^{-1}}$ (1)

(d) Would the roller coaster reach the speed you calculated in part (c)? Explain your answer. (2 marks)

- No. (1)
- Energy will be lost due to friction as heat and sound. (1)

6. A 10.0 g bullet travelling at $3.00 \times 10^2\ ms^{-1}$ passes through a piece of wood, slowing it down to $1.00 \times 10^2\ ms^{-1}$ in 2.50×10^{-2} s. How much work is done by the wood as the bullet passes through? (3 marks)

$$W = \Delta E_K = \frac{1}{2}mu^2 - \frac{1}{2}mv^2$$

$$= \frac{1}{2}m(u^2 - v^2) \quad (1)$$

$$= \frac{1}{2}(10.0 \times 10^{-3})\left[(3.00 \times 10^2)^2 - (1.00 \times 10^2)^2\right] \quad (1)$$

$$= \underline{4.00 \times 10^2\ J} \quad (1)$$