Oxford Cambridge and RSA

AS Level Physics B

H157/02 Physics in depth

Question Set 6

1 This question is about projectile motion.

Fig. 1.1 shows the path taken by an object thrown with an initial velocity v at a direction θ to the horizontal.

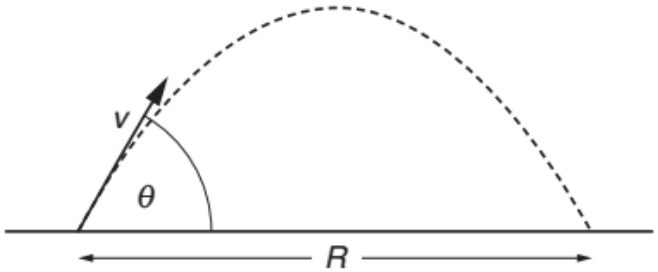

Fig. 1.1

(a) The range, R, of the projectile is given by $R = v \cos \theta t$ where t is the total time of travel of the projectile. Ignore air resistance.

(i) Show that the time t is given by the equation

$$t = \frac{2v\sin\theta}{g}.$$

[2]

(ii) Use the equation from part **(a)(i)** above to complete this table for a projectile of initial speed v = 24 m s^{-1} by adding the value of R for an angle of 76°.

θ/°	15	25	35	49	58	67	76
R/m	29.4	45	55.2	58.2	52.8	42.3	

Plot the new value of R on the graph in Fig. 8.2 following, draw a best-fit curve and determine the maximum range R_{max} for the projectile with initial speed 24 m s^{-1}.
g = 9.8 m s^{-2}

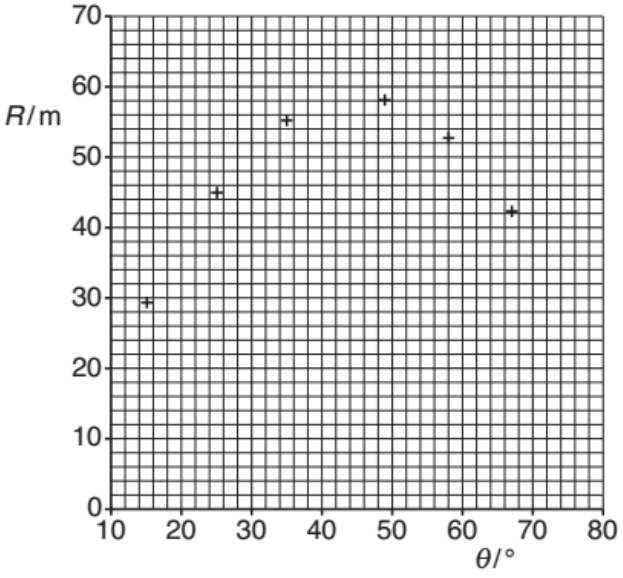

Fig. 1.2

R_{max} = ... m **[3]**

(b) A real projectile such as a tennis ball is greatly affected by air resistance.
State and explain how you would expect the R–θ graph for such a projectile, also thrown at 24 m s^{-1}, to differ from the theoretical graph of Fig. 9.2. **[3]**

(c) * Four athletics events involve throwing an object with the aim of achieving the largest range possible. These four are shown in **Fig. 1.3**.

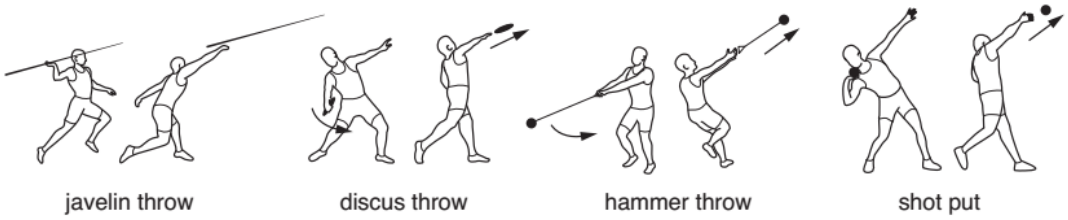

Fig. 1.3

The javelin is a sharp rod about 2.6m in length, the discus is a flat disc and both hammer and shot have metal spheres. For the javelin throw, the athlete runs a fixed distance before throwing. For the other three events, the athlete must remain within a marked circle during the throw. In each of these events, good performance depends on the power developed by the athlete and the impulse exerted on the thrown object.

The table shows data for these four events. All data refer to the men's competition.

event	hammer	discus	javelin	shot
mass of object thrown / kg	7.3	2.0	0.80	7.3
world championship record range / m	86.74	74.08	98.48	23.12

Discuss how the very different ranges achieved may depend on factors peculiar to each event.

[6]

[Question total: 14]

2 Carol and Jason are investigating momentum and energy changes in collisions.

They are using two trolleys on a table and measuring velocities with light gates connected to data-loggers. Each trolley has a pad of 'impact material' (rubber) attached to the front.

As each timing card passes through a light gate, it cuts a light beam and the attached data-loggerrecords the time for which the beam has been cut. **Fig. 2.1** shows the two trolleys approaching each other, having just passed through the light gates.

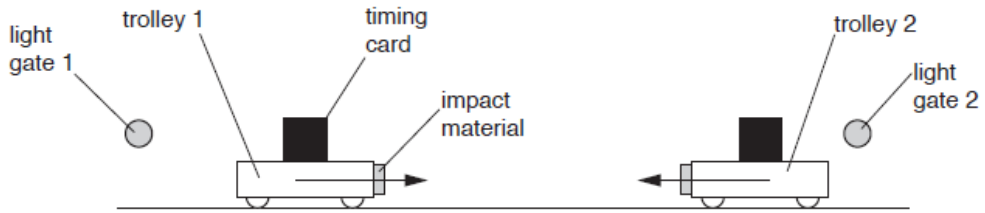

Fig. 2.1

(a) The data-logger and light gate together have a timing uncertainty of 4 μs. Typical timesrecorded in the experiment are in the range 0.1 s to 1.0 s.

The timing cards are each cut to be 10.0 cm wide in the direction of motion, and the uncertainty in the card width is ± 0.1 cm.

(i) Explain in terms of percentage uncertainty why the timing uncertainty can be ignored in this experiment. **[2]**

(a) (ii) The time recorded by the data-logger when a trolley passes the light gate is 0.1453 s.Calculate the mean speed of the trolley and its uncertainty.
Give both values to an appropriate number of significant figures.

mean speed =..... ± ..... m s^{-1} **[3]**

(b) The data for one collision are given below. After the impact, the two trolleys reversed direction and moved back outwards. Each trolley has a mass of 0.800 kg.

trolley 1			trolley 2		
before or after collision?	before	after	before or after collision?	before	after
time/s	0.1233	0.1645	time/s	0.1052	0.2123
v/m s^{-1}	0.811	−0.608	v/m s^{-1}	−0.951	0.471
p/kg m s^{-1}	0.649	−0.486	p/kg m s^{-1}	−0.761	0.377

(i) All the values of time are positive but some values of velocity and momentum are positive and some are negative. Explain this difference. **[1]**

(ii) Carol says, "These results seem to contradict the law of conservation of momentum." Evaluate this comment. **[3]**

(iii) Show that kinetic energy is **definitely** not conserved in this collision and suggest why this is the case. **[2]**

(c) * After a few trials of this method, Jason says, “I think the results we are getting here are too variable. We need to set this up in a way that lets us have the same initial velocities each time, so that we can get repeat readings to give better estimates of energy and momentum and their uncertainties. I think our timing method could be improved, too.”

Evaluate Jason’s comments and suggest ways in which Jason’s concerns could be addressed in order to obtain more accurate results in this investigation of conservation of momentum and energy. **[6]**

[Question total: 17]

Total Marks for Question Set 6: 31