LONDON SCIENCE COLLEGE

MARK SCHEME

PHYSICS

AS-Level

WORK, ENERGY AND POWER

TEST 2

Mark schemes

1 (a) *(use of gain in E_k = loss in E_p)*

$1/2mv^2 = mgh$

$1/2v^2 = 9.81 \times 8.0$ ✓

$(v = \sqrt{(2 \times 9.81 \times 8.0)}) = 13\ (12.5)\ (\text{m s}^{-1})$ ✓

Bald correct answer scores 1 mark

If use $v^2 = u^2 + 2as$ then zero

Unless resolved g along slope

If use 10 for g (–1)

Gets second mark if answer rounds to 13

1
1

(b) THREE FROM:

acceleration of truck in Fig.1 is constant ✓

In Fig.2

acceleration is greater/greatest at start/top ✓

acceleration decreases ✓

reference to zero acceleration/uniform velocity between C and D ✓

because the component of weight/acceleration parallel to the slope changes ✓

1
1
1
(3 max)

(c) the loss of (gravitational) potential energy is the same

hence gain in kinetic energy is the same ✓

1

(d) THREE FROM:

rain has no (initial) <u>horizontal</u> momentum ✓

<u>vertical</u> momentum of rainwater decreases ✓

there is no external (horizontal) impulse/force on the truck (and water system) ✓

mass (of truck) increases but speed/velocity decreases ✓

<u>horizontal</u> momentum of water increases (but horizontal momentum of truck decreases by same amount) ✓

(so) no change in (horizontal) momentum of truck <u>and</u> collected water/total momentum ✓

If say: 'vertical momentum/velocity of rain drops/water changes to horizontal (momentum/velocity)' score 2 marks

Cannot score last mark if stated that speed/velocity of truck does not change

1
1
1
(3 max)

[9]

2 **A**

[1]

3 (a) energy cannot be created or destroyed ✓

it can only be transferred / changed / converted from one form to another ✓

'Transformed' can be taken to mean transferred from one form to another.

2

(b) (i) (using $E_k = ½ mv^2$)

$2.2 = ½ × 0.40 × v^2$

v = 3.3 (ms^{-1}) ✓

Ignore errors in 3 sig fig.

Answer only can gain mark.

1

(ii) (using work done = $F × s$) 2.2 = F × 1.2 ✓ (F = 1.83 N) or

(using $a = (v^2 – u^2) / 2 s$)

$a = (0^2 – 3.32^2) / 2 × 1.2$ = (-) 4.59 (m s^{-1})

(F = ma) = 0.4 × 4.59 ✓ = (1.84 N)

A substitution of numbers are necessary for the mark

1

(iii) (work done in moving 0.2 m) = 1.8 × 0.2 (J) ✓ (= 0.36 J)

(allow ecf (bii) × 0.2)

total work done = 2.2 + 0.36 = 2.6 ✓ (same answer is achieved if F = 2N)

J or joule ✓

3

(iv) (use of energy = ½ F x)

$2.6 = ½ F_{max}$ 0.2

F_{max} = 26 N ✓

(allow ecf 10 × (biii))

Allow mark for answer only even for ecf.

1

[8]

4 GPE to KE and / or elastic potential (and reverse)

Energy is lost due to work done on air / trampoline

Work done by child (on trampoline) makes up for energy losses

No B1 mark for an incorrect energy change

Accept air resistance for an energy loss

[3]

5 **C**

[1]

6 (a) Calculation of energy = $12 \times 7.2 \times 10^4 = 8.64 \times 10^5$ J

Or time = 12000 / 1.5 = 8000 s ✓

Calculation of other quantity and substitution in power = useful energy / time taken ✓

Power = 110 (108 W) ✓

Or

Time = 8000 s ✓

Allow ecf for current or time

Current = charge / time = 9 A ✓

Power = VI = 108 (W) ✓

3

(b) Attempt to use Power / velocity ✓

Allow use of 100W for P

73 N ✓

Ignore inclusion of KE in calculation

If 108 used then answer is 72 N

If 100 used then answer is 67 N

or

work done = $F \times 12000$ ✓

equates to 110 × 8000 so F = 73 N ✓

allow ecf from 3.1

2

(c) Force parallel to slope = 120 × 9.81 × sin 4.5 = 92 N ✓

1

(d) Total resistive force = ans to (c) + ans to **(b)** (= 165 N) ✓

Allow ecf for incorrect F

Speed $= \left(\frac{100}{165} = \right) 0.61\ \text{m s}^{-1}$

Allow 0.66 / 0.67 if 108 W or 110 W used

2

(e) **Increasing the mass**

Reward discussion of compression of tyres

Reduces the range ✓

increases the friction on the bearings/tyres

OR More energy / power is used accelerating the user to the final speed

OR user and wheelchair have higher KE/ more energy to move ✓

Increasing the speed

Reduces the range ✓

Air resistance increases with speed ✓

Treat as independent parts

If not explicit about increasing / decreasing lose the first mark in each part

Within each part, second mark is dependent on the first

Allow opposite answers for decreasing mass / speed

4

[12]

7 (a) E_k E_p or $v = \sqrt{2gh}$ ✓

$= \sqrt{2 \times 9.81 \times 90}$

= 42.0 (m s^{-1}) ✓

First mark for realising energy transformation from GPE to KE.

Second mark for correct answer.

2

(b) calculation of area of pipe (=0.0833 m^2) ✓

radius = $\sqrt{\frac{0.0833}{\pi}}$ = 0.16 (m) ✓

2

(c) mass of water / s = 3500 kg ✓

energy available per second = 0.5 × 3500 × (42^2 − 12^2) ✓

= 2.8 ✓ MW ✓

4

(d) heat / mechanical friction in turbines ✓

friction at walls of pipes / turbulence ✓

electrical heating in wires ✓

*Do **not** allow (friction) bald.*

Seat of loss must be clear.

Max 2

[10]

8 **A**

[1]

9 D

[1]

10 C

[1]

11 A

[1]

12 (a) (i) 1000(N) AND 6000(N) seen

Independent marks

OR

$F = \sqrt{(1000)^2 + (6000)^2}$ ✓ allow incorrect values seen

= **6083** (N) (= 6100) ✓ More than 2 sf seen

Allow full credit for appropriate scale drawing

Ignore rounding errors in 3rd sig fig.

2

(ii) tanϴ = 1000 / 6000 or correct use of sin or cos ✓

ϴ = 9.5 (9.46°) ✓

Allow range 9.4 − 10.4

Use of cos yields 10.4

Allow use of 6100

Some working required for 2 marks.

Max 1 mark for correct calculation of vertical angle (range 79.6 − 80.6) some working must be seen

2

(iii) (*m* = *W*/*g* =) 6500 / 9.81 (= 662.6 kg) ✓

(*a* = *F* / *m* = 6083 / 662.6)

= 9.2 (ms^{-2}) ✓ (9.180)

Use of weight rather than mass gets zero

Correct answer on its own gets 2 marks

Penalise use of g=10 in this question part only (max 1)

2

(b) (i) = 6500 × 600 ✓ (662.6 × 9.81 × 600)
= 3 900 000 ✓ (J)

Look out for W x g x h which gives 39000000 (gets zero)
Correct answer on its own gets 2 marks
Do not allow use of 1/2 mv^2 (= 39 000)

2

(ii) (E= Pt =) 320 000 ×; 55 (= 17 600 k J)
OR P= 1(b)(i) / 55 (7.09 × 10^4) ✓
3.9 / 17.6 OR 70.9 / 320 OR = 0.22(16) ✓ ecf from first line

Some valid working required for 3 marks

conversion to a percentage (= 22 %) ✓

Look out for physics error: Power / time (320/55) then use of inverted efficiency equation yielding correct answer
Do not allow percentages >= 100% for third mark

3

[11]

Examiner reports

1 This question required an understanding of the vector nature of acceleration and momentum and also how using energy considerations can lead to a simpler analysis due to it being a scalar quantity.

(a) This was a straightforward calculation but a lot of students were caught out because they used $v^2 = u^2 + 2as$ instead of energy considerations. This meant that they did not get credit for their answer unless they allowed for the different directions of v, a and s.

(b) Some good responses were seen to this question although it was not uncommon for contradictory statements to be made. Most students were able to state that acceleration was constant in figure 1 but analysis of figure 2 proved more of a challenge. It was quite common to see answers that referred to speed rather than acceleration decreasing as the truck moved down the ramp. Also, a significant proportion of students thought that the truck decelerated between C and D. A quarter of students managed to gain all three marks.

(c) Only more able students could give a satisfactory explanation for the speeds being the same (19.8% correct).

(d) This was a challenging question that required a good understanding of momentum conservation in closed systems and also the importance of direction in momentum considerations. Very few students managed to give complete discussions. The commonest answer was that as mass went up momentum increased, with students failing to appreciate that with no external horizontal forces acting, this could not be the case. Better students did appreciate that the total horizontal momentum remains constant and so as mass increases speed must decrease. It was very rare for there to be a discussion of how the momentum of the rain water changes from vertical to horizontal. Nearly three-quarters of students failed to score on this question.

2 Students found this question challenging; there was a success rate of just over 20%. The most common incorrect response seen was distractor C. Quite often this was selected without any evidence of supporting calculations.

3 (a) Conservation of energy was well understood by most students. At the weaker end students wanted to add conditions such as 'in a system' or they only wanted to refer to some specific energy conversion. Sometimes students would refer to a 'change in energy' but not add 'from one form to another'.

(b) (i) A very easy question that students performed well in.

(ii) Students also performed well in this question with equal numbers using work equals force times distance to obtain the answer and others finding the acceleration first to use in Newton's second law equation.

(iii) Students had severe problems with this question. Even the unit of 'joule' was not given in the weaker responses. Most students felt the need to include a 'half' in the work done equation probably because the question included a reference to a spring. Also, very few added the kinetic energy given to the block.

(iv) With the use of an error carried forward students were more successful in calculating the maximum force. There was still fifty percent of students who could not calculate the maximum force because they failed to appreciate that the stored energy equation was required.

4 The majority of answers were limited to describing energy changes. Very few students considered energy losses, even though this was explicit in the question. Almost no answers addressed how the girl would return to the same height.

5 The most popular answer here was the correct answer (41% of students); certainly higher achieving candidates seemed confident with this calculation.

6 This question required students to apply their knowledge and understanding of physics to a battery-powered wheelchair. It gave students an opportunity to demonstrate knowledge and understanding in a range of areas including electrical and mechanical energy, power and force.

(a) This was a fairly accessible question with more than half of the students gaining all three marks. There was more than one route students could choose to answer this question, with the calculation of the current proving to be a popular alternative. 'Show that' questions provide students with an answer that can be used later should they be unable to do the calculation. It has become relatively common to see students attempting to use the value to perform the calculation backwards. It was more common to see answers that manipulated the numbers in the stem to obtain 100W. Students should be reminded that examiners will only give credit to the final answer in a 'show that' calculation if it is given to at least one more significant figure than the value in the question.

(b) Students were given full credit if they chose to use the value of 100 W from 03.1. Despite this, many students were unable to make at least some attempt at an answer, with over 10% making no attempt at all. It may be that many students were unfamiliar with questions that move from one area (such as electricity) to another (such as force), which could have led to the confusion of v (velocity) with V (pd) that was seen. Teachers should understand that this combination of topics within a question is a requirement of this specification, and the full A-level, that is certain to continue to appear in the examination papers. Errors were also seen in the answers that were provided. For example, asking for a 'mean' value of a quantity inevitably encourages some students to divide their answer by 2, an error that was seen a surprising number of times.

(c) Again, it may have been the context of this question that meant that this relatively straightforward calculation was only correctly performed by a minority of students. It may also have been partly due to the fact that only one mark is available and yet there are several opportunities for error, such as missing out ‘g’ and using the wrong trigonometrical function.

(d) The fact that a large number of students did not attempt this question is partly related to the need to use information from 03.2, which was not well answered. It could also suggest that students expect calculations involving speed (or velocity) to require the use of the “suvat” equations, for example, and that they are therefore confused when none of the familiar information is provided. However, it is acknowledged that this is a conceptually demanding question, requiring students to appreciate that, at the maximum speed, the driving force = the total friction/drag force for example, and then apply that to P = Fv.

(e) Another common feature of this new specification is the assessment of a student’s ability to reach a reasoned judgement. In this question students were required to decide which effect (increase or decrease) they were going to consider, and whether this would increase or decrease the range. This was a point missed by many students. Fully correct answers were rare, with many students failing to make the link between the speed and drag forces for example.

8 27% of students selected the correct answer here. Most students attempted to use equations of motion but failed to appreciate the direction of the acceleration and were unable to resolve to find the component of the weight parallel to the slope. Those who were successful most frequently used the principle of conservation of energy to find the work done by the frictional force.

12 (a) (i) Nearly all showed a 3 or 4 significant figure answer before rounding to 6100 and very few dropped marks here.

(ii) Some selected the wrong angle (angle to vertical rather than horizontal) but apart from that the question was very well done.

(iii) Generally well answered but the wrong force was sometimes used, e.g. 6000N rather than 6083N and sometimes weight was used rather than mass.

(b) (i) Most were successful here, but some thought 6500N was the mass and multiplied this by 9.81.

(ii) Some confusion over the calculation of useful power, with many candidates wrongly trying to calculate kinetic energy or calculating power from $P = Fv$. Some divided an *energy* by a *power*. The evidence suggests that many centres need to practice more of these questions.