MARK SCHEME

PHYSICS

AS-Level

WORK, ENERGY AND POWER

TEST 1

Mark schemes

1 (a) correct substitution into $P = Fv$

C1

180 (W)

A1

2

(b) higher power output/more air resistance

B1

refers to $P = Fv$ **and** states force (provided by cyclist) is greater while travelling at higher speed

B1

2

[4]

2 (a) (i) (one) **force** × distance between the **forces** ✓

(one) **force** × **perpendicular** distance between the **lines of action** or (one) **force × perpendicular** distance between the (two) **forces** ✓

2

(ii) (810 × 7.3 =) 5900 (5913) (or alternative correct method)

Nm ✓

2

(b) $P = Fv$ = (2 ×) 810 × 0.91 ✓

(1620 × 0.91) = 1500 ✓ (1474 W)

any number to 2 sf ✓

3

(c) to enable comparison between steam and horses

or mill owners/engineers etc needed to know which steam engine would be suitable

or would easily be able to compare the cost/time saved

or good marketing ploy for steam engines

or easily understood (by industrialists or the public)

or other suitable valid reason ✓

1

[8]

3 (a) (i) $F \propto \Delta L$ **(1)** up to limit of proportionality **(1)**

accept 'elastic limit'

$F = k\Delta L$ with terms defined gets first mark

2

(ii) straight line **(1)** through origin **(1)**

2

(iii) working shown and F ≥ 200 N **(1)** (500/0.385) = **1290** ± 20 **(1)**

N m^{-1} or N/m kg s^{-2} **(1)**

3

(b) (i) ($\Delta W = F\Delta s$) so area (beneath line from origin to ΔL) represents (work done or) energy (to compress/extend) **(1)**

work done (on or by the spring) linked to energy stored **(1)**

(area of triangle) = $\frac{1}{2} b \times h$ (therefore $E = \frac{1}{2} F\Delta L$) **(1)**

3

(ii) F = **360** (N) used **(1)** $P = \dfrac{\frac{1}{2} \times (360) \times 0.28}{1.5} = \dfrac{50.4}{1.5}$ **(1)** = **34**

(33.6) (W) **(1)**

ecf from wrong force

3

[13]

4 (a) 840 × 2.3

C1

1900 (J)/1930 (J)

A1

2

(b) (i) uses gradient

C1

data extraction correct –350 N, 0.3 m

C1

1170

A1

N m^{-1}

B1

4

(ii) uses area

B1

6.5 to 7.0 squares or 1 square is equivalent to
5 J/area is ½ base × height

B1

32.5 to 35 (J)

B1

3

[9]

5 (a) (i) 65 × 9.8 × 35 seen and evaluated to 22295 or 2231 or 22300J

B1

(ii) correct substitution of 65 kg and either 11000J or 18 m s^{-1} in ke formula seen

B1

18.4 (18.397) (m s^{-1}) to at least 3 sf

B1

(iii) distance = energy loss/force or work done/force or numerical equivalent

C1

64-64.3 using E_p = 20kJ or 79 – 81(m) using 22.3 kJ

A1

(iv) friction

B1

air resistance

B1

further detail eg friction at ski-ice surface

or caused by need to move air when passing through it

B1

8

(b) (i) time = Δ*v*/*a* or numerical equivalent

C1

6.4(3) – 6.6(6.57) (s)

A1

(ii) use of appropriate kinematic equation

C1

(57.8 – 60.4) 58 m or 60 (m) to 2 sf

A1

4

[12]

6 (a) (i) velocity is constant **(1)**

no acceleration **(1)**

(ii) 1.5 sin 50 = *D* cos 55 **(1)**

2.0 kN **(1)**

4

(b) (i) 1.15 kN **(1)**

(ii) total resistance to motion = 1200 + 1150 N **(1)**

use of power = Fv **(1)**

20 **(1)**

kW **(1)**

5

(c) boat now has resultant force of 1200 N acting on it **(1)**

boat will accelerate (until resistance of water = 2350 N) **(1)**

2

[11]

7

(a) F cos 20 = 300 gives F = 319 N **(1)**

(1)

(b) (i) work done = force × distance moved <u>in direction of force</u> **(1)**
F is not in the direction of motion **(1)**

(ii) work done = force × distance = 300 × 8000 = 2.4 × 10^6 J

(iii) power = $\dfrac{\text{work done}}{\text{time taken}}$ **(1)**

= $\dfrac{2.4}{5.0 \times (60 \times 60)} \times 10^6$ **(1)** (allow e.c.f. for work done in (ii))

= 133 W **(1)** (allow e.c.f. for incorrect time conversion)

(6)

(c) on the level, work is done only against friction **(1)**
uphill, more work must be done to <u>increase in potential energy</u> **(1)**
sensible conclusion drawn

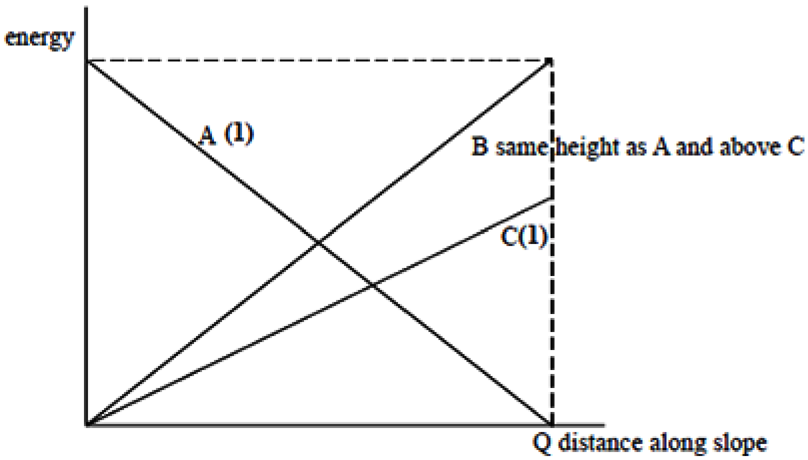
(e.g. increased work at constant power requires longer time) **(1)**

(3)

[10]

8

(a) (i) and (ii)



(iii) A + B = constant **(1)**
loss in potential energy = gain in kinetic energy <u>for A and B</u>
[or potential energy at P = kinetic energy at Q <u>for A and B</u>] **(1)**
reason for C being below B e.g. transfer to heat
[or work done against friction] **(1)**

(6)

(b) (i) clear reference to energy $v_C \left(= \sqrt{2gh}\right) = \sqrt{2 \times 9.8 \times 50}$ **(1)** = 31(.3) m s^{-1} **(1)**

(ii) $F \left(= \frac{mv_c^2}{r}\right) = \frac{80 \times (31.3)^2}{20}$ **(1)**

= 3.9(2) × 10^3 N

towards centre of circle **(1)**

(iii) gain in gravitational potential energy
(= mgh sin θ) = 620 × 9.8 × 60 × sin 20° **(1)**
= 1.25 × 10^5 J

(iv) 620 × 9.8 × 50 = (F × 60) (1) + 1.25 × 10^5 **(1)**
F = 3000 N **(1)**
alternative (iv)
calculation of acceleration = (–)8.0 m s^{-2} **(1)**
use of $F + mg \sin \theta = ma$ **(1)**
F = 3000 N **(1)**

(max 9)

[15]

9 B

[1]

10 B

[1]

Examiner reports

1 Most students were able to perform the straightforward power calculation in part (a), but few students were able to fully explain why the power output of the cyclist increased when cycling at a higher, constant speed. Students did not relate to the cyclist or his driving force and mainly stated that the air resistance had increased. The technical language used in the descriptions was often limited and lacked the thoroughness expected at this level.

2 Very few candidates knew the definition in part (a)(i). Many gave a vague description of a *couple*. Most simply defined a *moment* and these responses received no credit.

Despite not having known the definition of a moment of a couple, many went on to successfully calculate it in part (a)(ii). A few calculated 810 × d/2, instead of simply 810 × d. A significant number of candidates dropped marks by giving incorrect units. Typical errors were: N, Nm^{-1}, NM, and nm.

Many candidates got the calculation correct in part (b) though some did not multiply by two to take in to account the two horses. A significant number wrongly multiplied the torque (instead of the power) by the velocity to get 5400. A significant figure mark was applied to this question and a significant amount of candidates did not round to two significant figures; needlessly losing one mark.

Many candidates came up with very sensible answers in part (c). This requires that candidates ‘analyse and evaluate scientific knowledge and processes’. Therefore, the question required a little bit of thinking around science.

Very few candidates missed the question out. Many understood that a comparison was being made between steam engines and horses due to the widespread familiarity with the capabilities of the horse at that time.

3 The definition of Hooke’s law in part (a) (i) was done very well. Some missed the second mark by not mentioning the *limit of proportionality*.

Most candidates pointed out that the line was straight in part (a) (ii), but many did not score the second mark for saying that the line passed through the origin.

In part (a) (iii) many candidates either gave incorrect units, including Pa, J, Nm, or no units at all. Most correctly calculated the gradient, though some did not use a wide enough range to score full marks.

For part (b) (i), most candidates pointed out that energy stored is found from the area and that area is half base times height for a triangle. For the third mark, it was necessary to relate the area to the work done and this response was rarely seen. Work has been done on the spring to compress it (or work is done by the spring if it is being released) and the area represents the work done and therefore also the energy stored. Some lost marks because they explained how to calculate energy from the graph rather than how to derive the equation.

Surprisingly, only a relatively small number of candidates got full marks on part (b) (ii). Many used $P = Fv$ or $P = W/t$ and did not realise they would need to half their answer. A surprising number misread the force from the graph as 340 N, 370 N or 380 N rather than 360 N for instance. Another common error was to divide force by time (360/1.5) believing 360 to be the work done.

4 Most candidates correctly answered the calculation in (a), with the most common error being the introduction of a spurious factor of *g*. Nearly all candidates successfully completed the graph work in part (b).

5 Most candidates successfully completed part (a) (i).

Part (ii) was also successfully completed by a majority of the candidates.

The use of the equation for uniform decelerated motion was inappropriate in part (iii). Only a minority of the candidates appreciated that the work done had to be equated to the gravitational potential energy that had been transferred to forms other than to kinetic energy.

Only a small minority did not gain some credit in part (iv) and most stated friction and air resistance. A significant proportion of these did not identify where the friction was occurring. Vague answers such as between the skier and the ground were not accepted.

Most candidates completed part (b) (i) successfully.

Part (ii) was also done well by the majority of the candidates.

7 Part (a) was answered correctly by most candidates, although F = 300 cos 20 was seen rather frequently. Almost no candidates used sin 20. The explanation in part (b)(i) was generally not very clear. Few candidates stated explicitly that the work done by a force is found by multiplying the force by the distance moved *in the direction of the force* or that F was not moving in its own direction. Many of those candidates who earned the marks for part (i) then multiplied their answer to part (a) by 8000 (or, very often, 8) and arrived at an incorrect answer. Most candidates knew that *power* = *work done / time* in part (iii), but a significant number did not convert the 5 hours to seconds.

Most candidates found part (c) very difficult and only a very small number scored the maximum three marks available. An inability to express ideas clearly was seldom the problem: most made it adequately plain that they had misunderstood the physics of the situation. There were many answers in which energy transformations were not mentioned at all. Of those who did consider work and energy, most thought that all the work done by the force was converted into kinetic energy over level ground and that this kinetic energy was subsequently converted into potential energy on climbing the hill. A very few candidates successfully related the extra work needed in a climb to a longer time at constant power.

8 Only a few candidates scored high marks on this question. In parts (a)(i) and (a)(ii) the more able candidates drew the three graphs correctly, taking more care than has been the case in the past. It was often not possible to establish exactly which of the three graphs was being referred to in the many confused answers to part (a)(iii).

Part (b)(i) caused much confusion and many candidates did not know how to include the effects of the circular track. Attempting to work out angular velocity was a common error. Parts (b)(ii) and (iii) were much belier. Most candidates found part (b)(iv) to be conceptually very difficult.