Independent Revision Resource MS and examiner’s reports

Momentum, Impulse and Collisions Questions

**1.** (a) (i) (use of *F* = ma gives) 1.8 × 103 = 900 *a* **(1)**  
 *a* = 2.0 m s–2 **(1)**

(ii) (use of *v* = *u* + *at* gives) *v* = 2.0 × 8.0 = 16 m s–1 **(1)**  
 (allow C.E. for *a* from (i))

(iii) (use of *p* = *mv* gives) *p* = 900 × 16  
= 14 × 103 kg m s–1 (or N s) **(1)** (14.4 × 103 kg m s–1)  
 (allow C.E. for *v* from(ii))

(iv) (use of *s* = *ut* + ½*at*2 gives) *s* =× 2.0 × 82 **(1)**  
 = 64 m **(1)**  
 (allow C.E. for *a* from (i))

(v) use of *W* = *Fs* gives) *W* = 1.8 × 103 × 64 **(1)**  
 = 1.2 × 105 J **(1)** (1.15 × 105 J)  
 (allow C.E. for *s* from (iv))

[or *E*k = ½*mv*2 = ½ × 900 × 162 **(1)**  
 = 1.2 × 105 J **(1)**  
 (allow C.E. for *v* from (ii))] 9

The question, as a whole, proved to be a good discriminator. The various calculations in part (a) were quite demanding for a significant proportion of the candidates and unit errors were quite common for all the quantities involved, including those for the more straightforward quantities such as acceleration and speed.

Candidates were asked to sketch two graphs in part (b). This proved to be quite a difficult exercise with the non-linear, distance vs. time, graph being the most difficult to draw correctly.

Part (c) produced the same problems that questions of this type have produced in previous papers. Many candidates insisted on using Newton’s third law incorrectly and consequently getting into real trouble. Statements such as “the air resistance is the reaction to the driving force action” were common and were awarded zero marks.

**2.** (a) (i) (gravitational) potential energy to kinetic energy **(1)**

(ii) kinetic energy to heat energy  
[or work done against friction] **(1)** 2

(b) e.g. when using light gates  
place piece of card on trolley of measured length **(1)**  
card obscures light gate just before trolley strikes block **(1)**  
calculate speed from length of card/time obscured **(1)**

alternative 1: measured horizontal distance **(1)**  
 speed = distance/time **(1)**  
 time **(1)**

alternative 2: measure *h* **(1)**  
 equate potential and kinetic energy **(1)**  
 *v*2 = *gh* **(1)**

alternative 3: data logger + sensor **(1)**  
 how data processed **(1)**  
 how speed found **(1)** 3  
 QWC 2

Candidates found this question reasonably familiar and had more success, especially in part (a), than had been the case with similar questions in the past. In part (b), more candidates than previously seemed familiar with light gates and data loggers and were able to describe clearly the use of these devices. A minority of candidates had obviously studied a similar question in the January paper, a question which had required candidates to describe how the speed was measured after a collision. These candidates then tried to answer this question in the same way with the result that their answers were generally inappropriate.

Part (c) caused more problems than anticipated as many candidates misinterpreted the question and explained why the speed of the trolley might vary and not how.

**3.** A

[1]

**4.** (a) momentum before collision = momentum after collision **(1)**  
provided no external force acts **(1)** 2

(b) (i) *p = m* **(1)**

10 × 10–3 × 200 = 2.(0) **(1)** kg ms–1 (Ns) **(1)**

(ii) total mass after collision = 0.40 kg **(1)**  
0.40  **=** 2.0 gives  **=** 5.(0) ms–1 **(1)** (allow e.c.f. from (i)) 4

(c) (i) kinetic energy = m*v2*  
 = **(1)** (= 200 J)

(ii) kinetic energy =  **(1)** (= 5.0 J)

(iii) *Q =* 200 – 5 = 195 (J) =  **(1)**

=  = 78 K **(1)** (allow e.c.f. for incorrect *Q*) 5

(d) kinetic energy lost (= potential energy gained) = *mgh* **(1)**

*h* =  1.3 m **(1)** 2

[13]

This question was very well answered with many candidates scoring maximum or nearly maximum marks. Most candidates knew in part (a) that the momentum before a collision equalled the momentum after the collision, but rather few gave the condition that no external force must act on the system. Part (b) was almost always correct, although some candidates did not add the masses of the bullet and block.

Parts (c)(i) and (c)(ii) were usually correct. Insection (iii) some candidates failed to subtract the remaining kinetic energy of 5.0 J from the initial kinetic energy of 200 J, or alternatively used 5.0 J for the internal energy. Part (d) was most often correct, but a number of candidates used 2 *= u2* + 2*as* and scored no marks.

**5.** (a) (i) *E*p = *mg**h* **(1)**  
 = 5.8  10–2  9.8(1)  1.5 = 0.85 J 

(ii) 0.85 J **(1)**  
(allow C.E. for value of *E*p from (i))

(iii) (use of *E*k = ½*mv*2 gives) 0.85 = 0.5  5.8  10–2  *v*2 **(1)**  
 (allow C.E. for answer from (ii))  
(*v*2 = 29.3) *v* = 5.4 m s–1 **(1)**

(iv) (use of *p* = *mv* gives) *p* = 5.8  10–2  5.4 **(1)**  
 (allow C.E. for value of *v* from (iii))  
 = 0.31 N s **(1)** 7

(b)  *F* =  **(1)**  
 (allow C.E. for value of *p* from (iv))  
 = 31 N **(1)**  
[or *a* =  = 540 (m s–2) **(1)**  
*F* = 5.8  10–2  540 = 31 N **(1)**] 2

(c) egg effectively stopped in a longer distance **(1)**  
hence greater time and therefore less force on egg **(1)**  
[or takes longer to stop  
hence force is smaller as *F* = ]  
[or acceleration reduced as it takes longer to stop  
thus force will be smaller]

[or some energy is absorbed by container  
less absorbed by egg] 2

[11]

The calculations in parts (a) and (b) were well done although the unit for momentum produced the usual problems. Explaining the crumple zone in part (c) was often well answered although some candidates’ answers did tend to lack focus. The idea that the time duration of the collision was increased and that this was important, seemed to be well understood.

**Materials Topic**

**6.** (a) diagram showing two supported wires and vernier  
[or long wire and appropriate scale] **(1)**one justification of design **(1)**  
*measurements:*  
identified length with ruler **(1)**  
diameter with micrometer **(1)**in several places [or in different directions] **(1)**  
add load [mass] and read vernier **(1)**  
repeat for range of loads **(1)**within limit of proportionality [allow elastic limit] **(1)**  
calculation of at least one value from readings **(1)**  
graph or calc and average **(1)**  
if apparatus unsuitable, mark to scheme to max 6/8 max 8

(b) aluminium yields, has smaller yield strength identified from  
data sheet **(1)**  
use of *F*(=*sA*) **(1)**  
= 50 × 106 × ** × (0.36 × 10–3)2 **(1)**  
= 20.3N **(1)** 4

[12]

This question produced some very good answers.

Part (a) was a well-tried question on a topic well-known to almost all candidates. It was very pleasing to see a significant number of answers from candidates who had read the question carefully and who had, as judged from their answers, seen the experiment or carried it out themselves. This group of candidates drew a careful diagram and set out the procedural steps in order, following up with good detail of how to use the measurements made. Although few candidates failed completely to score any marks at all, there was a much larger group whose answers fell short of the ideal in several important respects. Those candidates who chose to use a single wire seldom scored many marks because they were unable to convince the examiner that the experiment described would give credible results. Single wire experiments are adequate, provided that the wire is stated to be sufficiently long and that there is some appropriate arrangement for determining the extension of the wire to a precision of less than one millimetre. Many answers omitted essential detail such as, for example, using a micrometer screw gauge to determine diameter and specifying the actual length of wire to be measured. In the treatment of results, most quoted correctly the Young modulus equation but many did not make the link between the mass added to the wire and the *tensile force* which resulted from the effect of gravity on it. Although references to graph plotting abounded, few candidates stated which variable was plotted on which axis, so rendering meaningless any discussion of the gradient of the graph. Not all of these errors or omissions appeared on every script but the presence of one or more in an answer had the effect of needless loss of marks.

Part (b) was generally answered well and many candidates scored full marks. Apart from (again) confusion over radius and diameter, the most common error was to use Young modulus data and not yield strength in part (b)(i). The conclusion is the same but the physical argument is incorrect.

**7.** (a) (i) gradient =  = 3.0 ms–2 **(1)**

(ii) distance is area under graph (to *t* = 0.1 s)  
or  × 0.7 × 2.1 0.3 **(1)** = 1.4(2) m **(1)** 3

(b) (i) *T* – *mg* = *ma* [or *T* = 1500(9.8+3.0)] **(1)**  
= 1.9 × 104 N **(1)**

*T* = *mg* = l.5 × 104 N **(1)**

(ii) EF **(1)** 4

(c) power = *F* or l.5 × 104 × 2.5 **(1)**  
= 3.7[3.8] × 104 W **(1)** 2

[9]

In this high-scoring question most of the difficulties arose in part (a), where candidates were not careful enough to distinguish between the straight part of the graph. AB, where the acceleration was uniform, and the curved part, BC. where it was not. Thus, a very common wrong answer in part (a)(i) was 2.5 ms–2 and even those candidates who recognised that they had to find the area under the graph up to C in part (a)(ii) most commonly treated that area as a triangle, giving the answer 1 .25m. Only a small proportion of the candidates calculated the area sufficiently accurately. Other mistakes included finding the area up to *t* **=** 0.7s or up to *t* **=** 4.3 s.

Answers to part (b) were better. The main weaknesses were inadequate explanation in part (b)(i) and carelessness in part (b)(ii).

**8.** uses slope of straight line region **(1)**  
slope = 1.54 × 105 (Nm–1) **(1)**  
*E* = slope ×  **(1)**  
*A* = 5.03 × 10–7 (m2) **(1)**  
*E* = 1.5 × 1011 Pa **(1)**  
*F*y = 87 (N) **(1)**  
yield stress = 1.7 × 108 Pa **(1)**

[6]

Except for those candidates who could not manipulate powers of ten correctly, many were able to work from graphical material to evaluate a Young modulus value. The subsequent yield stress calculation was done badly with many candidates simply quoting the yield force from the graph, often incorrectly. The exact region of the graph which indicated the *elastic* energy stored was not appreciated by many candidates. A significant number of scripts included a calculation of the whole energy, elastic and plastic.

**9.** (a) (i) tensile stress: the force per unit cross-sectional area **(1)**tensile strain: extension per unit length **(1)**

(ii) the Young modulus = tensile stress/tensile strain **(1)** 3

(b) (i) brittle: material A **(1)**

(ii) A, (brittle) obeys Hooke’s law (until it fractures without  
warning) **(1)**  
B, (ductile) obeys Hooke’s law up to the limit of proportionality **(1)**beyond this point wire is permanently stretched (or behaves  
plastically) **(1)**

(iii) A has greatest value of the Young modulus   
 because of steeper gradient **(1)** max 5

(c) (*Y* =  gives) 2.10 × 1011 =  **(1)**  
*e* = 0.44 × 10–3 m **(1)** 2

[10]

The definitions in part (a) were generally correct although many candidates lost a mark by defining the Young modulus as stress/strain rather than as tensile stress/tensile strain. Others gave an expression for the modulus but failed to define the terms in the expression.

There were some good answers to part (b) and candidates showed that they were familiar with terms such as Hooke’s law, elasticity, plasticity, yield point etc. The calculation in part (c) was usually carried out correctly.

10. (a) tensile stress: (normal) force per unit cross-sectional area (1)

tensile strain: ratio of extension to original length **(1)** 2

(b) (i) loading: obeys Hooke’s law from A to B **(1)**

B is limit of proportionality **(1)**

beyond/at B elastic limit reached **(1)**

beyond elastic limit, undergoes plastic deformation **(1)**

unloading: at C load is removed

linear relation between stress and strain **(1)**

does not return to original length **(1)**

(ii) ductile **(1)**

permanently stretched **(1)**

[or undergoes plastic deformation or does not break]

(iii) AD: permanent strain (or extension) **(1)**

(iv) gradient of the (straight) line AB (or DC) **(1)**

(v) area under the graph ABC **(1)** Max 9

(c) **(1)**

3.8(3) mm**(1)** 2

[13]

The definitions of tensile stress and tensile strain in part (a) were usually correct, the most notable omission being not defining *A* as the area of cross-section rather than just the ”area of the wire’.

There were some very good descriptions given in part (b) (i), but many candidates used the question as an opportunity to write everything they knew about stretching a wire, with elastic limit, yield point, break point etc. thrown around at random. For some reason, many candidates assumed the wire broke at the point C, but then went on quite happily to describe what happened as the masses were unloaded. The remainder of part (b) met with mixed success. The fact that the wire was ductile was usually well known and also what AD represented, although phrases such as ‘wire was deformed’ were not accepted, neither were the shape or size of the wire. It is quite obvious, and candidates should be made to realise it also, that the shape of the wire does not change when it is permanently extended. Parts (iv) and (v) in (b), suffered due to candidates not being precise, for example, the gradient of the graph was not sufficient; the line AB had to be specified. Likewise the area under the graph in (v) had to be the area under the graph ABC.

The calculation in part (c) was usually correctly performed.