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# Mark Scheme (Results)
# January 2010

GCE

## GCE Physics (6PH01) Paper 1

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**Mark scheme notes**

**Underlying principle**

The mark scheme will clearly indicate the concept that is being rewarded, backed up by examples. It is not a set of model answers.

For example:

(iii) Horizontal force of hinge on table top

66.3 (N) or 66 (N) **and** correct indication of direction [no ue] ✓ **1**
[Some examples of direction: acting from right (to left) / to the left / West / opposite direction to horizontal. May show direction by arrow. Do not accept a minus sign in front of number as direction.]

This has a clear statement of the principle for awarding the mark, supported by some examples illustrating acceptable boundaries.

**1. Mark scheme format**

1.1 You will not see 'wtte' (words to that effect). Alternative correct wording should be credited in every answer unless the ms has specified specific words that must be present. Such words will be indicated by underlining e.g. 'resonance'
1.2 Bold lower case will be used for emphasis.
1.3 Round brackets ( ) indicate words that are not essential e.g. "(hence) distance is increased".
1.4 Square brackets [ ] indicate advice to examiners or examples e.g. [Do not accept gravity] [ecf].

**2. Unit error penalties**

2.1 A separate mark is not usually given for a unit but a missing or incorrect unit will normally cause the final calculation mark to be lost.
2.2 Incorrect use of case e.g. 'Watt' or 'w' will **not** be penalised.
2.3 There will be no unit penalty applied in 'show that' questions or in any other question where the units to be used have been given.
2.4 The same missing or incorrect unit will not be penalised more than once within one question.
2.5 Occasionally, it may be decided not to penalise a missing or incorrect unit e.g. the candidate may be calculating the gradient of a graph, resulting in a unit that is not one that should be known and is complex.
2.6 The mark scheme will indicate if no unit error penalty is to be applied by means of [no ue].

**3. Significant figures**

3.1 Use of an inappropriate number of significant figures in the theory papers will normally only be penalised in 'show that' questions where use of too few significant figures has resulted in the candidate not demonstrating the validity of the given answer.

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**4. Calculations**

4.1 Bald (i.e. no working shown) correct answers score full marks unless in a 'show that' question.

4.2 If a 'show that' question is worth 2 marks then both marks will be available for a reverse working; if it is worth 3 marks then only 2 will be available.

4.3 **use** of the formula means that the candidate demonstrates substitution of physically correct values, although there may be conversion errors e.g. power of 10 error.

4.4 **recall** of the correct formula will be awarded when the formula is seen or implied by substitution.

4.5 The mark scheme will show a correctly worked answer for illustration only.

4.6 Example of mark scheme for a calculation:

'Show that' calculation of weight

| | | |
|---|---|---|
| Use of L × W × H | ✓ | |
| Substitution into density equation with a volume and density | ✓ | |
| Correct answer [49.4 (N)] to at least 3 sig fig. [No ue]<br>[If 5040 g rounded to 5000 g or 5 kg, do not give 3rd mark; if conversion to kg is omitted and then answer fudged, do not give 3rd mark]<br>[Bald answer scores 0, reverse calculation 2/3] | ✓ | **3** |

Example of answer:

80 cm × 50 cm × 1.8 cm = 7200 $cm^3$

7200 $cm^3$ × 0.70 g $cm^{-3}$ = 5040 g

5040 × $10^{-3}$ kg × 9.81 N/kg

= 49.4 N

**5. Quality of Written Communication**

5.1 Indicated by QoWC in mark scheme. QWC – Work must be clear and organised in a logical manner using technical wording where appropriate.

5.2 Usually it is part of a max mark.

**6. Graphs**

6.1 A mark given for axes requires both axes to be labelled with quantities and units, and drawn the correct way round.

6.2 Sometimes a separate mark will be given for units or for each axis if the units are complex. This will be indicated on the mark scheme.

6.3 A mark given for choosing a scale requires that the chosen scale allows all points to be plotted, spreads plotted points over more than half of each axis and is not an awkward scale e.g. multiples of 3, 7 etc.

6.4 Points should be plotted to within 1 mm.

- Check the two points furthest from the best line. If both OK award mark.
- If either is 2 mm out do not award mark.
- If both are 1 mm out do not award mark.
- If either is 1 mm out then check another two and award mark if both of these OK, otherwise no mark.

6.5 For a line mark there must be a thin continuous line which is the best-fit line for the candidate's results.

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| Question Number | Answer | Mark |
|---|---|---|
| **1** | C | **(1)** |
| | **Total for question** | **1** |

| Question Number | Answer | Mark |
|---|---|---|
| **2** | C | **(1)** |
| | **Total for question** | **1** |
| Question Number | Answer | Mark |
| **3** | B | **(1)** |
| | **Total for question** | **1** |
| Question Number | Answer | Mark |
| **4** | A | **(1)** |
| | **Total for question** | **1** |
| Question Number | Answer | Mark |
| **5** | D | **(1)** |
| | **Total for question** | **1** |
| Question Number | Answer | Mark |
| **6** | A | **(1)** |
| | **Total for question** | **1** |
| Question Number | Answer | Mark |
| **7** | C | **(1)** |
| | **Total for question** | **1** |
| Question Number | Answer | Mark |
| **8** | A | **(1)** |
| **9** | B | **(1)** |
| | **Total for question** | **2** |
| Question Number | Answer | Mark |
| **10** | B | **(1)** |
| | **Total for question** | **1** |

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| Question Number | Answer | Mark |
|---|---|---|
| **11(a)** | Describe terms<br><br>tough – able to absorb energy without failure (accept breaking/cracking etc) /<br>able to absorb a lot of energy in the plastic region /<br>withstand impact forces/shocks **(1)**<br><br>brittle – tends to shatter when subject to impact /<br>fails with little or no plastic deformation/behaviour/just beyond elastic limit **(1)** | **(2)** |
| **11(b)** | State type of behaviour<br><br>Plastic (deformation) **(1)** | **(1)** |
| | **Total for question** | **3** |

| Question Number | Answer | Mark |
|---|---|---|
| **12** | Label the fluid flow below and above A and describe each of them.<br><br>(Accept names on text lines instead of labels on diagram)<br>Below A = laminar or streamline **(1)**<br><br>Above A = turbulent **(1)**<br><br>Below A - no abrupt change in direction or speed of flow /<br>no mixing of layers / lines of flow don't cross<br>velocity/speed/direction at a point is constant /<br>layers parallel /<br>(no eddies is not sufficient) (smooth not sufficient) (ignore references to particles not mixing) **(1)**<br><br>Above A – mixing of layers / lines of flow cross /<br>contains eddies/whirlpools/vortices /<br>sudden changes in speed or direction /<br>velocity at a point is not constant<br>**(1)**<br><br>Allow the mark for the description if the name label is incorrect but the description matches the name.<br>Allow the mark for the description if it is in the correct place but the label is incorrect. | **(4)** |
| | **Total for question** | **4** |

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| Question Number | Answer | Mark |
|---|---|---|
| **13 (a)** | Show that this gives ultimate tensile strength of about 6 x $10^7$ Pa<br><br>Use of $W = mg$ **(1)** (do not award this mark if $g$ = 10 N/kg)<br>Use of stress = force / area **(1)**<br>Correct answer [6.3 x $10^7$ (Pa) to at least 2 sf] **(1) [no ue]**<br><br>(if F/A = 84/1.3 x $10^{-5}$ $m^2$ or they write 84 N/1.3 x $10^{-5}$ $m^2$ allow second mark only)<br><br>*Example of calculation*<br><br>$W = mg$<br>= 84 kg x 9.81 N/kg<br>= 824 N<br>stress = force/area<br>= 824 N/1.3 x $10^{-5}$ $m^2$<br>= 6.3 x $10^7$ Pa<br>(N.B. 'reverse show that', i.e. using 6 x $10^7$ Pa to get 79.5 kg gets 2 marks max) | **(3)** |
| **13 (b)** | Explain why the value for the sample may be lower<br><br>Explains<br>Masses added in 2 kilograms **(1)**<br>Required mass may have been between 82 and 84 kg / required mass may have been less than 84 kg / may need less than 2 kg extra **(1)** | **(2)** |
| **13 (c)** | Explain why the wood sample has the shape shown<br><br>Any of the following to a maximum of 2:<br>Maximum stress in the centre **(1)**<br>So it breaks in the right place **(1)**<br>(Wide at ends) for firm grip by supports **(1)**<br>Narrow in centre because breaking force proportional to area **(1)**<br>For a given force you get a larger stress **(1)**<br>So a smaller force/mass/weight is required to break it **(1)** | **(Max 2)** |
| **13 (d)** | What should be done to ensure reliable results<br><br>Repeat and average / repeat and identify anomalies / repeat to check **(1)** | **(1)** |
| | **Total for question** | **8** |

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| Question Number | Answer | Mark |
|---|---|---|
| **14 (a)** | Show that the work done by the horse in turning the wheel once was about 20 000 J.<br><br>Use of distance = 2 π *r* **(1)**<br>Use of work = force x distance **(1)**<br>Correct answer (19 000 (J) to at least 2 sf) **(1) [no ue]**<br>(If force x 3.7 m used, allow second mark only)<br>(If force x distance for 144 turns used, allow 1st and 2nd marks)<br><br>*Example of calculation*<br>$x$ = 2 x π x 3.7 m = 23.2 m<br>$W = F\Delta x$<br>=800 N x 23.2 m<br>= 18 600 J<br>('Reverse show that' starting from 20 000J – max 2) | **(3)** |
| **14 (b)** | Calculate the average power of the horse<br><br>Recall power is rate at which work is done (accept formula or substituted values) **(1)**<br>Substitute for 144 turns **(1)**<br>Correct answer (740 W) **(1)**<br><br>If using P = Fv:<br>Recall P = Fv **(1)**<br>Use of v = s/t for 144 turns **(1)**<br>Correct answer **(1)**<br><br>*Example of calculation*<br>Power = work done / time<br>= 144 x 18 600 J / 60 x 60 s<br>= 744 W (accept any dimensionally correct unit – ignore later units if W used as well)<br>(use of 20 000 J gives 800 W) | **(3)** |
| | **Total for question** | **6** |

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| Question Number | Answer | Mark |
|---|---|---|
| **15(a)** | Calculate maximum energy<br><br>Use of *gpe = mgh* **(1)**<br>Correct answer (0.28 J) **(1)**<br><br>*Example of calculation*<br>*gpe = mgh*<br>= 0.41 kg x 9.81 N kg$^{-1}$ x 0.07 m<br>= 0.28 J<br>[N.B. Bald answer gets 2, but no marks if derived from use of $v^2 = u^2 + 2as$] | **(2)** |
| **15(b)** | Resolve this velocity into horizontal and vertical components.<br><br>Shows a correct, relevant trigonometrical relationship **(1)**<br>Correct answer for horizontal component (12 m s$^{-1}$) **(1)**<br>Correct answer for vertical component (10 m s$^{-1}$) **(1)**<br>(max 1 mark total for reversed answers)<br>(apply ue once only)<br><br>*Example of calculation*<br>$v_h = v \cos\theta$<br>= 16 m s$^{-1}$ x cos 40°<br>= 12.3 m s$^{-1}$<br><br>$v_v = v \sin\theta$<br>= 16 m s$^{-1}$ x sin 40°<br>= 10.3 m s$^{-1}$ | **(3)** |
| **15(c)** | Explain another reason why the projectile does not go as far as expected.<br><br>(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate)<br><br>Max 2 out of three marking points for:<br><br>A physical cause – e.g. other parts of the machine are moving/the sling stretches/headwind/fired up a slope/the projectile increases in height before release **(1)**<br><br>Description of **energy** elsewhere than the projectile – e.g. elastic energy in sling/moving parts have ke / projectile has gained gpe before launch [Must refer to energy] **(1)**<br><br>Stating that less energy has been transferred to the projectile/projectile has a lower speed **(1)** | **(max 2)** |
| | **Total for question** | **7** |

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| Question Number | Answer | Mark |
|---|---|---|
| **16(a)** | (i) Explain how vertical distance travelled between 0.5 and 1.0 s can be found<br><br>Area under graph between 0.5 and 1.0 s / X and Y / these points **/**<br>Use average velocity between these points x time **(1)**<br>[Accept correct working with or without units, i.e. 0.5 x 4.8 x 0.5, and accept 4.4 instead of 4.8]<br><br>(ii) Explain how acceleration at Y can be found<br><br>Gradient of line at Y / of XY / of XZ / of YZ / at 1.0 s **(1)**<br>[Accept correct working with or without units, i.e. (-)4.8/0.5 or 9.6/1 and accept 4.4 instead of 4.8 or 8.8 instead of 9.6]<br>[If candidates give (i) 'area under graph' or 'average velocity' and (ii) 'gradient of graph' without specifying where on graph, allow one mark in total] | **(2)** |
| **16(b)** | Explain errors<br>(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate to be eligible for the 4th Physics mark)<br><br>**Max 2 per error for max 2 errors**<br><br>Lines not parallel **(1)**<br>Acceleration should be the same/both should have same gradient **(1)**<br><br>Max +ve and -ve speeds (from 0.5 s) all the same **(1)**<br>There will be some energy losses (bounce, air resistance) so max should have smaller magnitude each time **(1)**<br><br>Velocity at X/Z greater than that at the start **(1)**<br>Ball cannot gain energy **(1)**<br><br>Starts with a positive velocity **(1)**<br>but initial movement is down **(1)**<br><br>Starts with non-zero velocity / graph starts in wrong place **(1)**<br>From photo, it is dropped from rest **(1)**<br><br>There is a vertical line **(1)**<br>Bounce must take some time / acceleration can't be infinite etc<br><br>The graph shows a change in direction of velocity between 0 and 0.5 s / release and striking the ground **(1)**<br>It is travelling in one direction / down this whole time **(1)**<br><br>Graph shows an initial deceleration **(1)**<br>It is actually accelerating downwards **(1)** | **(max 4)** |

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| | | |
|---|---|---|
| | [Allow independent mark for second point in a pair if the context is not ambiguous, e.g. can't just say 'it is travelling downwards' without saying when] | |
| | **Total for question** | **6** |

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| Question Number | Answer | Mark |
|---|---|---|
| **17(a) (i)** | Show that the resultant upward force at the moment it is released is about 200 N<br><br>Use of density x volume **(1)**<br>Use of mass x *g* **(1)**<br>Correct answer [215 (N) to at least 2 sf] **(1) [no ue]**<br><br><u>Example of calculation</u><br>Mass of displaced air = density x volume<br>= 1.2 kg $m^{-3}$ x 2830 $m^3$ = 3396 kg<br>upthrust = weight of displaced air = 3396 kg x 9.81 N $kg^{-1}$ = 33 315 N<br>resultant force = 33 315 N – 33 100 N<br>= 215 N<br>[If candidate starts from difference in densities, apply mark scheme in the same way.] | **(3)** |
| **17(a) (ii)** | Find the initial upward acceleration<br><br>Use of $F = ma$ **(1)**<br>Correct answer [0.06 m $s^{-2}$] **(1)**<br><br><u>Example of calculation</u><br>$F = ma$<br>$a$ = 215 N / 3370 kg<br>= 0.064 m $s^{-2}$<br>[Use of 200 N gives 0.059 m $s^{-2}$] | **(2)** |
| **17(a) (iii)** | Justify that effect of air resistance is negligible<br><br>Use of Stokes' law equation, $F = 6\pi\eta rv$ **(1)**<br>Find viscous drag (6.0 x $10^{-3}$ (N)) **(1) (no ue)**<br>Relevant comment, e.g. **very** small **in comparison** to other forces (not just "small")/ **much** small**er** than other forces (not just smaller) **(1)**<br><br><u>Example of calculation</u><br>$F = 6\pi\eta rv$<br>$F$ = 6 x $\pi$ x 1.8 x $10^{-5}$ kg $m^{-1}$ $s^{-1}$ x 8.8 m x 2 m $s^{-1}$<br>= 6.0 x $10^{-3}$ N<br>This is very much less than upthrust and so is negligible | **(3)** |
| **17(b)** | Add labelled arrows<br><br>Correctly show weight (W, mg), upthrust (U), and viscous drag /drag/friction/air resistance (V, F, D)<br>3 correct = 2, 2 correct = 1<br>[4 labels, max 1 for 3 correct forces, zero for 2 correct forces, 5 labels or more = zero]<br>[Forces do not need to be co-linear. Accept two correct labels on the same arrow. Accept buoyancy force for upthrust] | **max (2)** |

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| | | |
|---|---|---|
| | [Do not accept 'gravity'] | |
| **17(c)** | Explain why this density change limits the height to which the balloon will rise.<br><br>Mass/weight of displaced air decreases / upthrust decreases / density of air in balloon eventually equals density of surrounding air [accept density greater than surrounding air] **(1)**<br><br>Net upward force would decrease / no resultant upward force / no more upwards acceleration **(1)** | **(2)** |
| | **Total for question** | **12** |

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| Question Number | Answer | Mark |
|---|---|---|
| **18 (a)** | Explain why the coin on the ruler has no horizontal motion<br><br>Max 2 points – (Max 1 if no reference to force / friction)<br>Initially at rest **(1)**<br>(Smooth surface so) no friction **(1)**<br>No horizontal force / only vertical forces **(1)**<br>So (from Newton's first law) no horizontal acceleration / no change in horizontal velocity **(1)** | **(Max 2)** |
| **18(b)** | Explain how this demonstrates the independence of horizontal and vertical motion<br><br>They have **the same** vertical acceleration / force / motion / (instantaneous) velocity **(1)**<br>Although only one has horizontal motion/velocity **(1)** | **(2)** |
| **18(c)** | Show that the coin on the ruler strikes the ground with a speed of about 4 $ms^{-1}$<br><br>Use of $v^2 = u^2 + 2as$ OR Use of $mgh = ½ mv^2$ Or other correct combinations of equations of motion **(1)**<br>Correct answer (4.1 m $s^{-1}$) **(1)**<br><br>*Example of calculation*<br>$v^2 = u^2 + 2as$<br>$v^2$ = 2 x 9.81 m $s^{-2}$ x 0.85 m<br>= 4.1 m $s^{-1}$ | **(2)** |
| **18(d)** | Calculate the velocity at which it strikes the ground.<br><br>Use of distance/time for horizontal speed **(1)**<br>Use of Pythagoras with velocity components **(1)**<br>Correct answer for resultant velocity magnitude [4.9 m $s^{-1}$] **(1)**<br>Use of trigonometrical function with velocities for the angle **(1)**<br>Correct answer for angle [58°] **(1)**<br><br>OR<br>Use of distance/time for horizontal speed **(1)**<br>Use of trigonometrical function with velocity components for the angle **(1)**<br>Correct answer for angle [58°] **(1)**<br>Use of trigonometrical function for the resultant velocity magnitude **(1)**<br>Correct answer for resultant velocity magnitude [4.9 m $s^{-1}$] **(1)**<br><br>[Allow ecf from mark 3 of the calculation in this question]<br><br>*Example of calculation*<br>$v = s/t$ = 1.1 m / 0.42 s = 2.6 m $s^{-1}$<br>$v^2 = v_h^2 + v_v^2$ | **(5)** |

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| | | |
|---|---|---|
| | $= (2.6 \text{ m s}^{-1})^2 + (4.1 \text{ m s}^{-1})^2$<br>$v = 4.9 \text{ m s}^{-1}$<br>from horizontal, tan (angle) = $4.1 \text{ m s}^{-1} / 2.6 \text{ m s}^{-1}$<br>angle = 58°<br>(N.B. Use of $4 \text{ m s}^{-1}$ gives and answer of $4.8 \text{ m s}^{-1}$ and 57°) | |
| | **Total for question** | **11** |

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| Question Number | Answer | Mark |
|---|---|---|
| **19 (a)** | Explain whether the band obeys Hooke's law.<br><br>States:<br>Line not straight / line curves / gradient not constant / k not constant **(1)**<br>(But) Hooke's law states extension or change in length is proportional to force **(1)**<br><br>[Allow both marks for: No, because extension is not proportional to force]<br>[Accept coherent references to 'the variables' for force and extension] | **(2)** |
| **19(b)** | Show that energy stored is below 0.8 J<br><br>Indication of use of area (could be marks on graph) / use of ½ $Fx$ **(1)**<br>Calculation of value as good as triangle approximation (0.6 J) **(1)**<br>More detailed, e.g. counting squares, for correct answer (0.76 J) **(1)** (accept answers above from 0.7 J to just below 0.8 J)<br><br>[If a candidate shows it is less than 0.8 J by drawing a shape with area of 0.8 J, 1st mark as above, 2nd mark for correct 0.8 J shape, 3rd for making comparison.] | **(3)** |
| **19(c)** | Calculate of initial speed of aeroplane<br><br>Equates stored energy with initial kinetic energy of aeroplane **(1)**<br>Use of ke = 1/2 $mv^2$ **(1)**<br>Correct answer (7.5 m $s^{-1}$) **(1)**<br><br>*Example of calculation*<br>0.76 J = 1/2 $mv^2$<br>$v$ = √(2 x 0.76 J / 0.027 kg)<br>= 7.5 m $s^{-1}$<br>[Allow use of 0.8 J for energy instead of ecf from 19 (b), or allow an obvious 'less than 0.8 J' if a candidate hasn't got their own value and is attempting to continue, but it must not be less than 0.6 J]<br>[Use of 0.6 J gives 6.7 m $s^{-1}$; use of 0.8 J gives 7.7 m $s^{-1}$] | **(3)** |
| **19(d) (i)** | Describe energy transfers<br><br>energy transferred to (elastic) strain energy / elastic potential energy of band (and some heat) **(1)**<br>(elastic) strain energy / elastic potential energy / this energy decreases and some energy transferred to heat **(1)**<br><br>[Ignore references to sound] | **(2)** |

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| | | |
|---|---|---|
| | | |
| **19(d) (ii)** | Explain effect on initial speed<br><br>(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate to be eligible for the 3rd Physics mark)<br><br>Area under graph for increasing force > area for decreasing force /<br>one line higher than the other /<br>gap between lines **(1)**<br><br>Work done by band less than calculated energy stored /<br>energy stored > energy retrieved /<br>area between lines is energy transferred to heat/<br>area between lines is energy dissipated **(1)**<br><br>not all energy is transferred to kinetic energy **(1)** | **(3)** |
| | **Total for question** | **13** |

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