BRITISH PHYSICS OLYMPIAD

2010 Physics Challenge

Mark Scheme and Notes for Teachers

Thank you for entering the 2010 Physics Challenge. Please note the following information:

Before the test

- It is intended that the paper should be taken on Friday 12th March. However, if this is not possible, any date during the period 8th –18th March will be acceptable.

During the test

- The paper lasts one hour.
- Candidates may use any calculator and should write their answers directly on the exam script.

After the test

- Teachers should mark their students' scripts. The mark scheme begins overleaf.
- Medals are awarded in the following manner

Award	Gold	Silver	Bronze	Participation
Mark Range	50 – 38	37 – 31	30 - 20	19 – 0

- Free certificates can be claimed for participating students. To order certificates please go to http://www.physics.ox.ac.uk/olympiad/Enter.html

- The scripts of any Gold Medallists (those scoring 38 or above) should be sent to the address below for consideration in the national competition. Please ensure the student's name and school is written clearly. Scripts must arrive by Monday 29th March to be considered for a national prize.

BPhO Office, Clarendon Laboratory, Parks Road, Oxford, OX1 3PU

- Five outstanding Gold Medallists, together with their teachers will be invited to the BPhO Presentation Ceremony at The Royal Society in London on Thursday 29th April 2010.

If you have any further questions please contact us on schools.liaison@physics.ox.ac.uk

Physics Challenge 2010 - Mark scheme

Please award marks as indicated below.

Equivalent valid reasoning should gain equal credit to the solutions presented here.

Error carried forward marks may be awarded where an incorrect answer is used as part of the data needed for a subsequent question, providing that the resulting answer is not plainly ridiculous.

If incorrect units are used more than once then **one** mark should be deducted from the total.

If an inappropriate number of significant figures are given more than once in final answers then **one** mark should be deducted from the total.

Section 1 – Multiple Choice Questions

1	2	3	4	5	6	7	8	9	10
C	E	D	B	B	C	E	A	C	C

Section 2 – Short Answer Questions

Marks for these two questions should be awarded for a clear explanation of the underlying Physical principals using correct scientific terminology. Answers that are incomplete, contain errors in Physics or use terminology incorrectly cannot be awarded full credit.

Award 0 marks:	No valid attempt made to answer question
Award 1 mark:	Valid point presented but other-wise incorrect or incomplete answer
Award 2 marks:	Partially correct answer but major error or omission in reasoning
Award 3 marks:	Mostly correct answer, only minor errors or omissions in reasoning
Award 4 marks:	Completely correct answer, no errors, omissions of reasoning or incorrect use of terminology

Question 11. (4 max)

- Air trapped between glass panes is a good insulator
- Which prevents heat loss due to conduction
- The glass reflects the infra-red radiation emitted by warm objects in the room
- Which prevents heat loss due to radiation

Also allow credit for correct reference to convection but an answer that does not refer to convection can still be awarded full marks

Question 12. (4 max)

- Current in filament makes filament hot
- A hot (metal) filament has a higher electrical resistance than a cold filament
- The higher resistance means that less current flows (than when the filament was cold)
- Eventually filament reaches a constant temperature and so current remains constant

Section 3 – Longer Questions

Question 13

(a)

- Drag force = Weight (at terminal velocity) [1]
- Area of sphere = π x 0.5^2 = 0.79 m^2 [1]
- Use of $mg = kAv^2$ gives v $\simeq$ 27 m/s [1]

(b)

- The terminal velocity would be higher [1]
- Because the volume and hence cross sectional area (A) is smaller meaning that v must be higher to give the same drag force [1]

(c)

- Use of $mg = kAv^2$ [1]
- To give A $\simeq$ 5.7 m^2 [1]

(d)

- Use of $D = kAv^2$ to calculate D $\simeq$ 2900 N (allow ecf) [1]
- Use of W = mg to calculate W = 400 N [1]
- Use of Resultant = D - W to give Resultant force $\simeq$ 2500 N (ignore sign) [1]

(e)

- Initial acceleration = 10 m/s^2 [1]
- Curve showing acceleration reducing to zero after some time [1]
- Acceleration goes from zero to -63 m/s^2 "instantly" when parachute opened [1]
- Curve showing acceleration returns to zero some time later [1]

The curves should be approximately exponential i.e. not a straight line
The acceleration of the object immediately after the parachute opens is given by the answer to (d) so allow ecf as necessary (2500/40 $\simeq$ 63 m/s^2)

(14 max)

Question 14

(a)

- Use of f = 1 / T to give f = 2 Hz [1]

(b)

- Distance travelled by ripple in 0.5 s is 4.5 cm … and ….
- Distance travelled by source in 0.5 s is 2.0 cm [1]
- Therefore distance between successive wavefronts is 2.5 cm [1]
- Ripples travel at 9 cm/s so time between wavefronts at X is 2.5 / 9.0 $\simeq$ 0.28 s [1]

(c)

- Use of f = 1 / T to give f = 3.6 Hz [1]

(d)

- Use of period, T = 1/300 s [1]
- Use of similar argument to (b) to give distance between successive sound waves to be (340 – 5) / 300 ≃ 1.12 m [1]
- Giving time between successive wavefronts as 1.12 / 340 ≃ 0.00329 s [1]
- Use of f = 1 / T to give f ≃ 304 Hz [1]

(9 max)

Question 15

(a)

- Labelled diagram showing Venus closer to the Sun [1]
- Sun – Venus – Earth angle ≃ 90° [1]

Ignore any errors in scale

(b)

- 90 degrees (allow perpendicular) [1]

(c)

- Use of distance = speed x time and appreciation that total distance travelled is twice the distance to Venus to give: [1]
- distance = $2.9979 \times 10^8 \times 692.43 / 2 = 1.0379 \times 10^{11}$ m = 103.79×10^6 km

(d)

- Sun does not have a solid surface and so radar is not easily reflected [1]

(e)

- Use of angle = 46 + (12/60) + (49/3600) [1]
- To give angle = 46.2136° (at least 3 decimal places required) [1]

(f)

- Right angled triangle gives Earth-Sun distance = Earth-Venus distance ÷ cosine (Sun-Venus angle) [1]
- Distance = $103.79 \times 10^6 / \cos(46.2136) = 149.99 \times 10^6$ km (expect 5 sig fig) [1]

(9 max)