Physics Challenge 2015 Mark-scheme

Preamble:

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 <u>more than once</u> then **one** mark should be deducted from the total.

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

Section 1 – Multiple Choice Questions   [1 mark each]

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

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.

Markers are **encouraged to be generous** and award credit where possible.

Award 0 marks: No valid attempt made to answer question

Award 1 mark: Single valid point presented but other-wise incorrect or incomplete

Award 2 marks: Partially correct answer but major error(s) or omission(s) in reasoning

Award 3 marks: Mostly correct answer, only minor error(s) or omission(s) in reasoning

Award 4 marks: Essentially correct answer, no errors or omissions of reasoning but answer is not clear on first reading, is confused or uses terminology incorrectly

Award 5 marks: Completely correct answer, no errors, omissions of reasoning or incorrect use of terminology, clear on first reading

Any valid explanation should be awarded credit

Example solutions might include, but are not limited to:

11.   Voltages in a circuit   [5 marks]
   - Cell transfers electrical energy to the charge carriers / electrons at a rate of ε joules per coulomb
   - In the bulbs, electrical energy is transferred to heat and light at a rate of V joules per coulomb
   - Charge is conserved / charge carriers are not "used up"
   - For a given charge carrier making one complete journey around the circuit, conservation of energy requires that the energy gained is equal to the energy given up
   - Therefore $\varepsilon = V_1 + V_2$
   - Accept explanation in terms of a clear analogy

12.   Accelerating elevator   [5 marks]
   - Person is accelerating
   - Therefore there must be an unbalanced force acting on them
   - Their weight doesn't change
   - The reaction force from the floor increases (to provide an upward resultant force)
   - The reaction force increasing (on their feet) is the sensation of feeling heavier

Section 3 – Longer Answers

(a)(i)   The mirror rotates during the flight time and …   [1]

        must be realigned in exactly the position shown to reflect through the gap   [1]

(a)(ii) 1/8th revolution = 45 degrees   [1]

(a)(iii) Conversion from rpm to rps   [1]

        time to turn 1/8th turn = 2.42×10^{-4} seconds   [1]

        distance travelled = 72,000 m   [1]

        speed = $72,000 / 2.42 \times 10^{-4}$ = 2.98×10^{8} m/s (accept rounded values)   [1]

        Note: accept any number of significant figures i.e. 3×10^{8} m/s gains full credit

(b)(i)   Time of flight = 0.5×10^{-6} s   [1]

        Distance travelled = 120 m   [1]

        Speed = 2.4×10^{8} m/s   [1]

(b)(ii) Intensity reduced due to beam spreading out / being absorbed / stray

        reflections from prism / any credible answer   [1]

(c)(i)   Correct axes, labels and scale   [1]

        Points plotted correctly   [1]

        Line of best fit   [1]

(c)(ii) Evidence: Non-zero intercept at D=0   [1]

        Effect: Time too big and so calculated velocity too small   [1]

(c)(iii) Speed = 2 x gradient   [1]

        Gradient = $90 / ((0.7 - 0.1) \times 10^{-6})$ m/s   [1]

        Speed = 3×10^{8} m/s   [1]

(d)   Offset / systematic error stated as 0.1 μs (or their value if reasonable)   [1]

        Use of offset / systematic error to give Δt = 0.27 μs to 0.28 μs   [1]

        Flight time in air = $(4 \times 7.5$ m$)/3 \times 10^{8}$ = 0.1 μs   [1]

        Flight time in water = 0.17 μs to 0.18 μs and distance = 40 m   [1]

        Therefore speed = 2.2×10^{8} m/s to 2.4×10^{8} m/s   [1]

        (3 out of 5 marks available if offset not recognised giving Δt = 0.37 μs to 0.38 μs
        and corresponding speed as 1.43×10^{8} m/s to 1.48×10^{8} m/s)

        Note: Use their value of the offset from the graph, suggested answers for
        guidance only, full credit can be given for answers outside the stated range if
        working correct and offset from graph reasonable.

(e)(i)　TIR described / diagram suitably drawn　　　　　　　　　　　　　[1]

　　　　include reference to critical angle < 45° for glass　　　　　　　　[1]

(e)(ii)　Beam returned parallel to incoming beam (a retroreflector) OR

　　　　Less light lost / absorbed, no secondary reflections　　　　　　　[1]

(e)(iii)　Path length in prism ≈ few cm (recognised as a short distance)　　　[1]

　　　　Overall path length ≈ 70 m and so % of path in glass is very small　　[1]

　　　　Resolution of oscilloscope is not good enough to measure the effect (owtte)　[1]