HODDER Education

Physics review
www.hoddereducation.com/physicsreview

Volume 33, Number 4, April 2024

Answers

Practice-for-exam questions

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Galileo's inclined plane: the world's first particle accelerator

1 **a**

u = 0 m/s
a = 9.81m/s^2
t = 3 s

$$s = ut + \frac{1}{2}at^2$$

$$s = 0m/s \times 3s + \frac{1}{2}9.81m/s^2 \times 3s^2$$

$$\underline{s = 44.15m}$$

b

$$g = \frac{f}{l} = \frac{44.15m}{5m}$$

$$\underline{g = 8.83}$$

c Frictional forces between the ball and the slope, and perhaps even air resistance.

Rocket propulsion

1 **a**

Use G = $6.67 \times 10^{-11}\,N\,m^2\,kg^{-2}$

$$v = \sqrt{\frac{2GM}{r}} = \sqrt{\frac{2 \times (6.67 \times 10^{-11}\ Nm^2kg^{-2}) \times (7.3 \times 10^{22})}{1.75 \times 10^6}}$$

$$\underline{v = 2360ms^{-1}\ or\ 2.36kms^{-1}}$$

b

$$v = \sqrt{\frac{2GM}{r}} = \sqrt{\frac{2 \times (6.67 \times 10^{-11}\ Nm^2kg^{-2}) \times (7.3 \times 10^{22})}{1.17 \times 10^6}}$$

$$v = 2890ms^{-1}\ or\ 2.89ms^{-1}$$

2 Let the mass of the rocket be m_r, and the mass of the fuel be m_f. We want to find m_r.

$$v = v_e \ln\left(\frac{m_f + m_r}{m_r}\right)$$
$$e^{\frac{v}{v_e}} = \frac{m_f + m_r}{m_r}$$
$$m_s e^{\frac{v}{v_e}} = m_f + m_r$$
$$m_r e^{\frac{v}{v_e}} - m_r = m_f$$
$$m_r\left(e^{\frac{v}{v_e}} - 1\right) = m_f$$
$$m_r = \frac{m_f}{\left(e^{\frac{v}{v_e}} - 1\right)}$$

$$m_f = 2\,500\,000kg,\ v = 12kms^{-1},\ v_e = 4kms^{-1}$$

$$m_r = \frac{2\,500\,000kg}{\left(e^{\frac{12kms^{-1}}{4kms^{-1}}} - 1\right)}$$

$\underline{m_r = 131\,000kg}$

Lasers

1

Use h = $6.63 \times 10^{-34} js$, $c = 3 \times 10^8 ms^{-1}$, and 1J = 6.24×10^{18}eV

$$E = hf = \frac{hc}{\lambda}$$
$$\lambda = \frac{hc}{E}$$
$$\lambda = \frac{6.63 \times 10^{-34}Js \times 3 \times 10^8 ms^{-1}}{E}$$

$$E = 1.9eV \div 6.24 \times 10^{18} = 3.04 \times 10^{-19}J$$
$$E = 2.6eV \div 6.24 \times 10^{18} = 4.17 \times 10^{-19}J$$

$$\lambda_1 = \frac{6.63 \times 10^{-34}J \times 3 \times 10^8 ms^{-1}}{3.04 \times 10^{-19}J} = 6.54 \times 10^{-7}m \text{ or } 654nm$$

$$\lambda_2 = \frac{6.63 \times 10^{-34}Js \times 3 \times 10^8 ms^{-1}}{4.17 \times 10^{-19}J} = 4.77 \times 10^{-7}m \text{ or } 477nm$$

$\underline{\lambda_1 = Red}$
$\underline{\lambda_2 = Blue}$

Taking repeat measurements

1 **a** Attempt 3, data point 3 (7.2) and Attempt 2, data point 5 (11.7)

b Uncertainties are most simply calculated as the difference between the mean value and the data point furthest from this value. More sophisticated methods generally produce smaller uncertainties.

Data point 1: mean = 13.0, uncertainty = 0.2

Data point 2: mean = 8.3 (to 1 s.f.), uncertainty = 0.4

Data point 3: mean = 5.5 (to 1 s.f.), uncertainty = 0.4

Data point 4: mean = 8.0 (to 1 s.f.), uncertainty = 0.3

Data point 5: mean = 13.0 (to 1 s.f.), uncertainty = 0.2

c Systematic error