

2007 Physics Trial Exam 1 Solutions

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Motion in one and two dimensions

Q1 Apparent weight = reaction force = $72 \times 10 = 720 \text{ N}$

Q2 B, C

Q3 Take upward as the positive direction.

Net force on Tom = $+720 + (-75 \times 10) = -30 \text{ N}$

Acceleration of elevator = acceleration of Tom

$$= \frac{F_{net}}{m} = \frac{-30}{75} = -0.4 \text{ ms}^{-2}$$

Magnitude of acceleration = 0.4 ms^{-2} .

Q4 Vertical component: $u = 20 \sin 30^\circ = +10$, $a = -10$, $s = -10$,

use $s = ut + \frac{1}{2}at^2$ to find t . $-10 = +10t + \frac{1}{2}(-10)t^2$, $t = 2.7 \text{ s}$

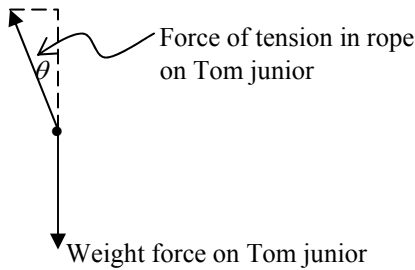
Q5 Conservation of energy: $\frac{1}{2}mv_A^2 + mgh_A = \frac{1}{2}mv_B^2 + mgh_B$,

$$\therefore v_A^2 + 2gh_A = v_B^2 + 2gh_B, 20^2 + 2(10)(10) = v_B^2 + 2(10)(0),$$

$$v_B = 24.5 \text{ ms}^{-1}$$

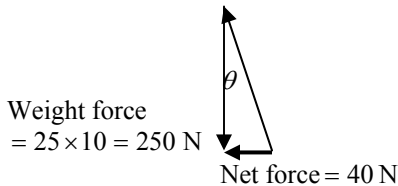
Q6 F

Q7



Q8 Net force = centripetal force = $\frac{mv^2}{r} = \frac{25 \times 2.0^2}{2.5} = 40 \text{ N}$

Q9



$$\tan \theta = \frac{40}{250}, \theta = \tan^{-1}\left(\frac{40}{250}\right) = 9^\circ$$

Q10 Work required

= area under force-compression graph from 0 to 0.05 m
 $\approx 10 \text{ J}$

Q11



Q12 Kinetic energy = potential energy in spring

$$\frac{1}{2}(27)v^2 = 10, v \approx 0.9 \text{ ms}^{-1}$$

Q13 B

$$Q14 v = \frac{2\pi r}{T}, \therefore r = \frac{vT}{2\pi}$$

$$a = g, \frac{v^2}{r} = \frac{GM}{r^2}, v^2 r = GM, \frac{v^3 T}{2\pi} = GM,$$

$$v = \sqrt[3]{\frac{2\pi GM}{T}} = 3.9 \times 10^3 \text{ ms}^{-1}$$

$$Q15 \text{ Tom's weight} = mg = \frac{mv^2}{r} = \frac{2\pi mv}{T} = 42 \text{ N}$$

Q16 Impulse = change in momentum

$$F_{av} \Delta t = mv - mu$$

$$5.0 \times 1.2 = 25v - 0, v = 0.24 \text{ ms}^{-1}$$

Electronics and photonics

$$Q1 \text{ Since } V_1 = 0, \frac{R_1}{R_2} = \frac{750}{500} = 1.5$$

$$Q2 \text{ Voltage across } 750\Omega \text{ resistor} = \frac{750}{500} \times 2.4 = 3.6 \text{ v}$$

$$\therefore \text{voltage across } R_3 = 3.6 + 2.4 = 6.0 \text{ v.}$$

Current through $R_3 = 10.8 \text{ mA} = 1.08 \times 10^{-2} \text{ A.}$

$$R_3 = \frac{V}{I} = \frac{6.0}{1.08 \times 10^{-2}} = 560 \Omega$$

Q3 When the LED is in conducting mode, the voltage across it is fairly constant. C.

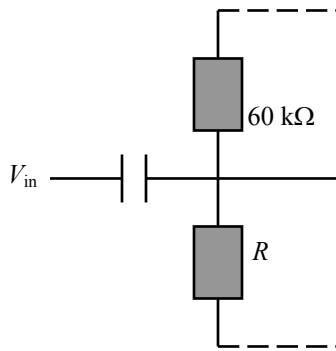
$$Q4 \text{ Voltage gain} = \text{gradient of } V_{out} - V_{in} \text{ graph} = -\frac{12}{0.40} = -30.$$

Q5 $V_{cc} = 12 \text{ v}$; $V_{p-p} = 2.2 - 1.8 = 0.40 \text{ v}$; $V_{out} = 0 \text{ v}$

Q6 Base voltage of the npn transistor is centred at 2.0v. ∴ voltage across R is 2.0v and voltage across 60kΩ-resistor is 10v.

$$\frac{R}{60} = \frac{2.0}{10}, \therefore R = 12 \text{ k}\Omega.$$

Q7



A capacitor is added to the circuit (see above) to remove the constant component of the signal before it is sent to the amplifier.

Q8 The information (e.g. small voltage signal from a CD player) in analogue form (i.e. as a continuous variation of voltage) causes the voltage across the 1Ω-resistor and hence the laser diode to vary, and the optical power of the laser diode varies accordingly resulting in the emission of intensity modulated light.

Q9 Gradient of graph $m = \frac{1.2 - 0.1}{4.4 - 2.9} = \frac{1.1}{1.5}$

$$\Delta P = m\Delta V = \frac{1.1}{1.5} \times 0.10 = 0.073 \text{ mW}$$

Investigating materials and their use in structures

Q1 Resolve the reaction force 115 N into horizontal and vertical components. The horizontal component gives rise to compressive stress, and the vertical component shear stress.

$$\text{Compressive stress} = \frac{F_{\text{hori}}}{A} = \frac{115 \sin 55^\circ}{0.15 \times 0.050} = 1.3 \times 10^4 \text{ Nm}^{-2}$$

$$\text{Shear stress} = \frac{F_{\text{vert}}}{A} = \frac{115 \cos 55^\circ}{0.15 \times 0.050} = 8.8 \times 10^3 \text{ Nm}^{-2}$$

Q2 Horizontal component $F_{\text{net}} = 0$,

$$+115 \sin 55^\circ + T \sin 60^\circ = 0, T = 110 \text{ N (108.8 N)}$$

Q3 Vertical component $F_{\text{net}} = 0$,

$$+115 \cos 55^\circ + 108.8 \cos 60^\circ - mg = 0, m = 12 \text{ kg}$$

Q4 The structure (i.e. the plank) is in equilibrium, net torque must be zero.

Q5 Tensile strength = 140 MNm⁻²

$$\text{Young's modulus} = \text{gradient} = \frac{140}{0.02} = 7000 \text{ MNm}^{-2}$$

$$\text{Strain energy} = \text{area under graph} = \frac{1}{2}(140)(0.02) = 1.4 \text{ MJm}^{-3}$$

Q6 Fracture occurs in the vicinity of the linear region.

Q7 Brittle. B

Q8 Glass is stronger in compression than in tension due to the existence of fine cracks in it. While the inside is hardened (cooling) in the manufacturing process, it contracts and causes the already hardened outside under compressive stress. So the finished product is under permanent compressive stress, i.e. toughened.

Q9 $\sigma = E\varepsilon, \therefore \varepsilon = \frac{\sigma}{E} = \frac{2.1}{35000} = 6.0 \times 10^{-5}$ or $6.0 \times 10^{-3}\%$

Q10 Ordinary glass is brittle because fine cracks developed naturally when it is made. However if molten glass is drawn into long thin fibres there are few fine cracks appearing and glass becomes a tough material in fibre form. When the glass fibres and the resin are moulded together the fibres reinforce the brittle resin, and the finished composite material becomes strong and tough with its strength proportional to the fibre content.

Please inform physicsline@itute.com re conceptual, mathematical and/or typing errors