2009 Physics Trial Exam 1 Solutions

Area of study 1 – Motion in one and two dimensions

Q1 $\text{Speed} = \dfrac{90}{3.6} = 25\ \text{ms}^{-1}$.

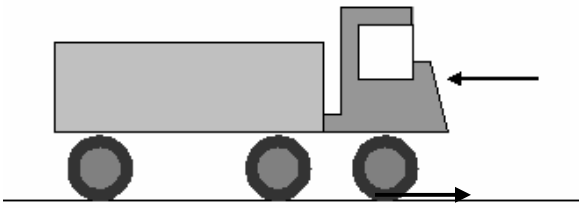
Q2 Vertical component: $u = {}^{+}25\sin 80°$, $a = {}^{-}10$, $v = 0$.
$v^2 = u^2 + 2as$, $s = {}^{+}30.3$ m. Max. height above the takeoff point is approx. 30 m.

Q3 Free fall is motion under gravity only. B, C and E.

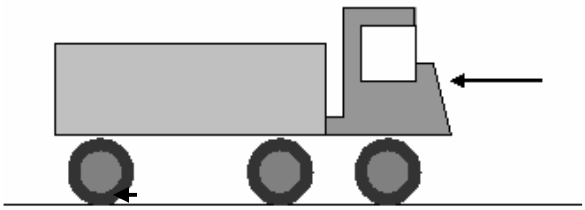
Q4 Δp = area under force-time graph
$= \dfrac{1}{2}(2800)(5.0\times10^{-3}) = 7.0\ \text{kg ms}^{-1}$.

Q5 Average net force over the 5.0 ms interval (1.5 cm displacement) $= \dfrac{\Delta p}{\Delta t} = \dfrac{7.0}{5.0\times10^{-3}} = 1400$ N.
ΔE_k = work done by the average net force
$= 1400\times(1.5\times10^{-2}) = 21$ J.

Q6



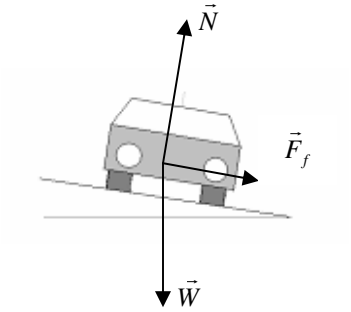
Q7



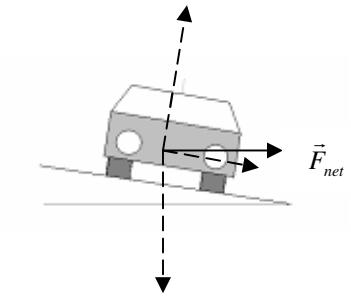
Q8 In a minute, displacement $= 30\times60 = 1800$ m.
Work done $= 5200\times1800 = 9.4\times10^6$ J.

Q9 Momentum is not conserved because the tanker is not isolated (resistive force). When the tanker becomes lighter, rolling friction and hence resistive force decrease. Assuming the same driving force of 5200 N, there will be a net force on the tanker to speed up its motion.

Q10



Q11



Q12 $F_{net} = \dfrac{mv^2}{r} = \dfrac{1200\times15^2}{60} = 4500$ N towards the centre of the turn.

Q13 A banked road (i) creates an extra horizontal component of normal reaction force and thus the centripetal force required to make a turn is less reliant on friction force as its source,
(ii) increases the normal reaction force on the car during the turn and thus increases the maximum friction force between the tyres and the road. Hence the maximum allowable speed is increased.

Q14 Conservation of energy: $\Delta E_k = \Delta E_p$,
$\dfrac{1}{2}(0.11)v^2 = 0.11(10)(0.30)$, $v^2 = 6.0$, $v = 2.45$.
$F_{net} = \dfrac{mv^2}{r}$, $R + 0.11(10) = \dfrac{0.11(6.0)}{0.25}$, $R \approx 1.5$ N.
Apparent weight ≈ 1.5 N.

Q15 Velocity at B: $\dfrac{1}{2}(0.11)v^2 = 0.11(10)(0.80)$, $v = 4.0$.
Impulse $= \Delta p = 0.11({}^{-}2.45) - 0.11({}^{+}4.0) \approx {}^{-}0.71$ Ns,
i.e. ${}^{-}0.71$ Ns left.

Q16 $a = g = 2.57\times10^{-3}\ \text{ms}^{-2}$.

Q17 $\dfrac{g_e}{g_a} = \dfrac{r_a^{\,2}}{r_e^{\,2}}$, $g_e = \dfrac{r_a^{\,2}}{r_e^{\,2}}\times g_a = \left(\dfrac{r_a}{r_e}\right)^2 \times g_a$
$= 4^2\times(2.57\times10^{-3}) = 4.11\times10^{-2}\ \text{Nkg}^{-1}$.

Q18 $\dfrac{T_e^{\,2}}{r_e^{\,3}} = \dfrac{4\pi^2}{GM_{sun}} = 3.0\times10^{-19}\ \text{s}^2\text{m}^{-3}$ (or equivalent units).

Area of study 2 – Electronics and photonics

Q1 When both switches are off, all four light globes operate at the correct voltage. Total power = $1.5 \times 4 = 6.0$ W.

Effective resistance = $\dfrac{V^2}{P} = \dfrac{6^2}{6.0} = 6.0\ \Omega$.

Q2 When only S_A is switched on, it connects two points of the same potential, $\therefore$ zero current passes through it. $\therefore$ switching on S_A does not affect the brightness of the light globes.

Q3 When only S_B is switched on, L_3 will be shorted and it goes off. This exposes L_4 to a potential difference of 6 V, which is well over its rating and causes it to burn out. L_1 and L_2 are not affected by switching on S_B because they remain at 3 V each.

Q4 Same current (75 mA) flows through the diode and the resistor in series. From the graph, diode voltage is 0.70 V, and resistor voltage is 5.0 V.
$\therefore$ power supply voltage = $0.70 + 5.0 = 5.7$ V.

Q5 $R = \dfrac{V}{I} = \dfrac{0.70}{75 \times 10^{-3}} \approx 9.3\ \Omega$.

Q6 | O | D | M | I |

Q7 B and D.

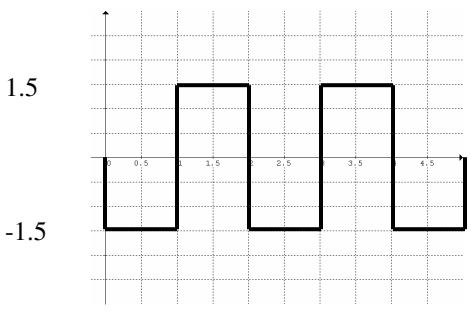
Q8 The photodiode does not face the infrared LED directly and the inside surface of the chamber is non-reflecting, no infrared light from the LED will reach the photodiode. If smoke enters the chamber, the smoke particles scatter the infrared light in all directions and some will reach the photodiode. This causes an increase in diode current to trigger the alarm.

Q9 B. Photodiode is reverse biased.

Q10 Voltage gain = gradient of the linear section
$= \dfrac{\Delta v_{OUT}}{\Delta v_{IN}} = \dfrac{-1.5}{20 \times 10^{-3}} = -75$.

Q11 Peak-peak output voltage
= 25 mA × 75 = 1875 mA ≈ 1.9 V.

Q12



Detailed study 2– Investigating materials and their use in structures

1	2	3	4	5	6
B	C	A	C	A	B

7	8	9	10	11	12	13
C	C	C	D	D	B	D

Q1 The bottom of the column is compressed by the load and the weight of the **whole** column. B

Q2 Compress stress is due to the weight of the truck. Shear stress is due to friction between the tyres and the ground. C

Q3 Net force is zero because the weight force and the normal force are equal and opposite. Net torque is zero because the two forces are on the same line of action. A

Q4 Side length of square = $\sqrt{0.16} = 0.40$ m,
$\theta = \tan^{-1}\left(\dfrac{0.40}{0.80}\right) \approx 26.6°$.
Max. whole number of degrees **before** toppling over = 26. C

Q5 Tensile strength = max. stress before failing.
Elastic limit = max. stress in the linear section. A

Q6 Total energy absorbed = area under the graph ≈ 1.5 J. B

Q7 From graph, strain = $1.8 \times 10^{-3} = 0.18\%$. C

Q8 The material with the same elastic limit and strength, and the greatest Young's modulus. C

Q9 Permanent deformation: $\sigma > 450$ MPa.
Without breaking under tensile/compressive stress:
$\sigma < 600$ MPa. $\therefore 450 < \sigma < 600$. C

Q10 D

Q11 $\vec{T}_X + \vec{T}_Y + \vec{R} + \vec{W} = \vec{0}$, $\therefore \vec{T}_X + \vec{T}_Y + \vec{R} = -\vec{W} = {}^{+}750$ N. D

Q12 $\vec{\tau}_X + \vec{\tau}_Y + \vec{\tau}_R + \vec{\tau}_W = \vec{0}$,
$\therefore \vec{\tau}_X + \vec{\tau}_Y + \vec{\tau}_R = -{}^{-}750 \times 1.8 = {}^{+}1350$ Nm. B

Q13 T_X can vary from 0 up to the breaking force (or the force required to keep the plank in equilibrium) when it acts alone. T_Y can also vary from 0 up to the breaking force (or the force required to keep the plank in equilibrium) when it acts alone. $\therefore$ when both act together, there is not enough information to determine whether $T_X < T_Y$, $T_X = T_Y$ or $T_X > T_Y$. D

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