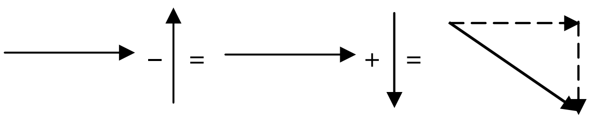
2008 Physics Trial Exam 1 Solutions

Area of study 1 – Motion in one and two dimensions

Q1 Velocity of Y relative to X = $\boldsymbol{v}_Y - \boldsymbol{v}_X$ (vector subtraction)

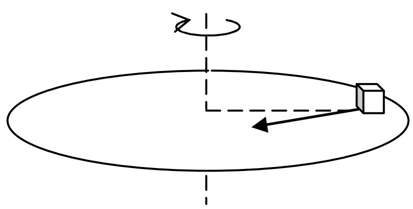


$\therefore$ D

Q2 Speed = $\sqrt{35^2 + 42^2} \approx 55$ kmh^{-1}

Q3 Same answer as Q1 because $\boldsymbol{v}_X$ and $\boldsymbol{v}_Y$ remain the same after both cars have crossed the intersection.

Q4



Q5 The rotating platform is a non-inertial frame of reference because it accelerates. The acceleration arises from the rotation and the increase in the speed of the rotation. If you carry out motion experiments on the rotating platform, you will find Newton's laws of motion are not valid.

Q6 Maximum friction $= \mu N = \mu mg$

Net force $F = \frac{mv^2}{r}$, $\therefore \mu mg = \frac{mv^2}{r}$,

$v = \sqrt{\mu gr} = \sqrt{0.20 \times 10 \times 2.5} \approx 2.2$ ms^{-1}

Q7 Tom is in free fall for 34m. Taking downward as the positive direction, $u = 0$, $a = +10$, $s = +34$. Use $s = ut + \frac{1}{2}at^2$ to find t. $34 = \frac{1}{2} \times 10t^2$, $t \approx 2.6$ s

Q8 Use the law of conservation of energy:
Total energy at the bridge = total energy at the water level
Gravitational potential energy = elastic potential energy

$mgh = \frac{1}{2}kx^2$,

$k = \frac{2mgh}{x^2} = \frac{2 \times 72.0 \times 10 \times 51}{(51-34)^2} \approx 254$ Nm^{-1}

Higher k, unable to reach the water level; lower k: will get wet.

Q9 $a = 0$, net $F = 0$, $mg - kx = 0$,

$x = \frac{mg}{k} = \frac{72.0 \times 10}{254} \approx 2.8$ m (extension). $34 + 2.8 = 36.8$ m below the bridge.

Q10 Total energy at the bridge = total energy at the water level
Kinetic energy + grav. potential energy = elastic potential energy

$\frac{1}{2}mv^2 + mgh = \frac{1}{2}kx^2$,

$\frac{1}{2}(71.8)V^2 + 71.8(10)(51) = \frac{1}{2}(254)(51-34)^2$

$V \approx 1.54$ ms^{-1}

Q11 At the highest point, vertical component of velocity = 0.
Horizontal component of velocity

$= \frac{displacement}{time} = \frac{50.4}{2.64} \approx 19.1$ ms^{-1}.

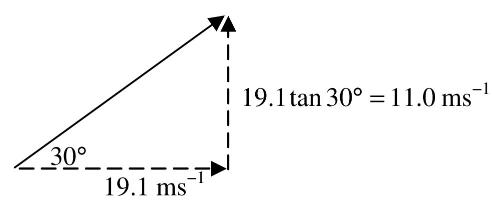
Speed ≈ 19.1 ms^{-1}.

Q12 The acceleration is due to gravity, $a = g = 10$ ms^{-2}.

Q13 From the moment of taking off to the moment just before landing, the change in momentum equals the impulse exerted by gravity on Tom and the motorbike.
The time in flight = 2.64 s
Force of gravity = $mg = 252 \times 10 = 2520$ N downwards
Impulse = $F\Delta t = 2520 \times 2.64 \approx 6.65 \times 10^3$ Ns downwards
Change in momentum $\approx 6.65 \times 10^3$ kgms^{-1} downwards
(Note: incorrect unit given in the trial exam)

Q14 Consider Tom, the motorbike and the earth as the isolated system when the law of conservation of momentum is applied.

Q15



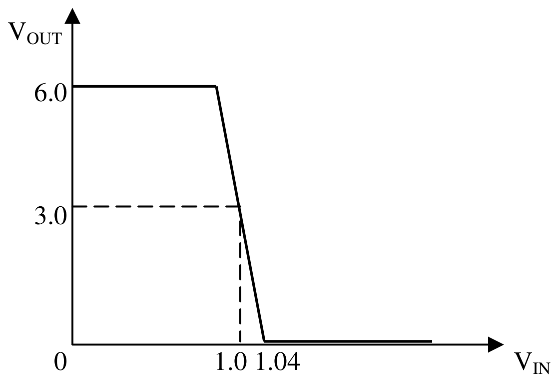
Consider the vertical component. Take upward direction as positive. $u = +11.0$, $a = -10$, $t = 2.64$, use $s = ut + \frac{1}{2}at^2$ to find $s = -5.75$ m.
Height = 5.75 m.

Area of study 2 – Electronics and photonics

Q1 Voltage gain $= \dfrac{\Delta V_{OUT}}{\Delta V_{IN}} = \dfrac{-1.5}{20\times10^{-3}} = -75$.

Q2 $I_c =$ current gain $\times I_b = 100\times8.0\times10^{-6} = 8.0\times10^{-4}$ A, or 80 mA.

Q3 Voltage supply = 6V DC, voltage gain = −75, the centre of the linear region is at $V_Y = 3.0$ V when $V_X = 1.0$ V.
$\therefore$ the V_{OUT} versus V_{IN} graph (voltage-transfer characteristics) of the npn transistor is:

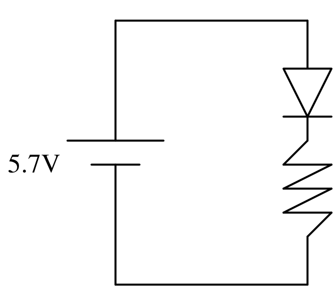


If the original input signal is applied at point X directly, then the voltage at point X is 1.00 + 0.10 ± 0.02 = 1.10 ± 0.02 V, which is in the lower plateau of the V_{OUT} versus V_{IN} graph.
Hence $V_{OUT} \approx 0$.

Q4 B. Saturation.

Q5 To bring the signal back to the centre of the linear region of the voltage amplifier, the dc voltage at point X must be at 0.90V, so that 0.90 + 0.10 ± 0.02 = 1.00 ± 0.02 V
$\therefore \dfrac{R_1}{R_3} = \dfrac{V_1}{V_3} = \dfrac{6-0.9}{0.9} = \dfrac{5.1}{0.9} \approx 5.7$.

Q6



Q7 Resistance $= \dfrac{V}{I} = \dfrac{5}{0.05} = 100\,\Omega$

Q8 Voltage across diode = 0.70V
Voltage across resistor = 5.7 − 0.7 = 5.0V
From graph, current through resistor = 50 mA.
Since the diode and the ohmic resistor are in series,
$\therefore$ current through diode = 50 mA.

Q9 D.

Q10 From graph, R = 5 kΩ.

Q11

Current (μA)	**Temperature** (°C)
110	5
300	25
660	***39***

Q12 At lower temperatures the thermistor has a much higher resistance. Higher resistance results in lower current through the thermistor and hence lower self-heating of the thermistor. Thus at low ambient temperature the thermometer measures the temperature accurately because it is less affected by self-heating of the thermistor at high ambient temperature.

Detailed study 2
– Investigating materials and their use in structures

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

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

Q1 $y = \dfrac{(4\times12)\times6+(4\times8)\times4+(4\times12)\times6}{(4\times12)+(4\times8)+(4\times12)} = 5.5$ OR
$y = \dfrac{(12\times12)\times6-(4\times4)\times10}{(12\times12)-(4\times4)} = 5.5$ B

Q2 The centre of mass is $(6,5.5)$, $\therefore \tan\theta = \dfrac{6}{12-5.5}$,
$\theta \approx 42.7°$ D

Q3 Perpendicular to the wall through O. C

Q4 Torque of applied force about O
$= F_{app}d_\perp = 30\times(20\sin 60°) \approx 5.2$ Nm C

Q5 |Torque of friction about O| = |torque of app. force about O|
$F_{friction}\times(0.80\times10^{-2}) \approx 5.2$, $F_{friction} \approx 650$ N B

Q6 The bolt is under shear stress. C

Q7 As Tom climbs up the ladder, the ladder presses harder against the wall, $\therefore$ the normal reaction N of the wall on the ladder increases.   A

Q8 Consider the vertical forces on the ladder:

R normal reaction of the floor on the ladder
F_f frictional force of the wall on the ladder
W_L weight force of the ladder
W_T weight force of Tom on the ladder

$R = W_L + W_T - F_f$

$R = 1000 - F_f$

When Tom is at the bottom rung of the ladder, F_f is relatively small and $R < 1000$.
When Tom is not on the ladder $R \approx W_L = 280$.
$\therefore 350 < R < 950$ is the best estimate.   D

Q9 B, C, D

Q10 Steel has a much higher stiffness than timber.   B
Corrugated iron sheets are much lighter than roof tiles.   C

Q11 A

Q12 Area under graph $\approx 430\times10^6 \times 0.1 = 4.3\times10^7$ J   A

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

