2014 NJC H1 Physics Paper 2 Suggested Solutions

1a 0.01x25 = 0.25mm = 0.3 mm

Hence, not possible as the instrument cannot read up to the 2^{nd} dp.

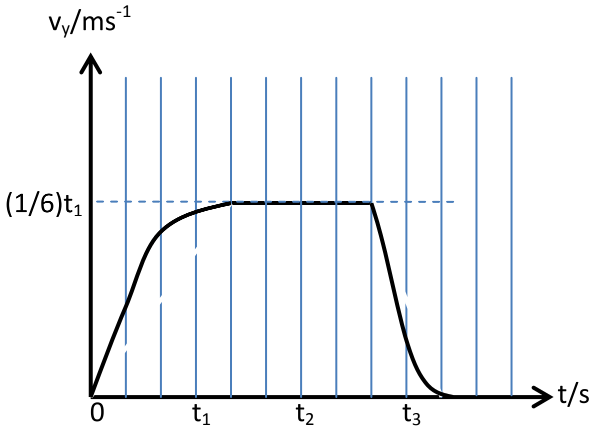
1b Taking average of a few readings could reduce the scatter of the readings from one another. Hence, random error is reduced since random error is a measure of the scatter of the data points.

1c The statement is incorrect. The kinetic energy of a body is equal to half its mass times the square of the **value of** its velocity. Since the calculation consists of the multiplication of scalar values, the result is a scalar value and not a vector.

2a One-dimensional motion and constant acceleration.

2bi The passengers has gone to a higher floor. Positive acceleration points in the upwards direction. Area under the a-t graph gives the change in velocity. The two areas under the graph are equal and opposite in value. Thus, lift moves upwards initially, increasing in speed. It then travels in constant velocity for some time before slowing down and stopping.

2bii



2ci Taking a path similar to path 2,

Time of flight = $2V_o\sin\alpha/g$, where V_o is initial speed and α is the angle V_o make with horizontal

Horizontal Range = Horizontal velocity x time of flight

$= V_o^2 \text{Sin } 2\alpha / g$

Hence, $V_o^2 \text{Sin } 90^o / g = V_o^2 \text{Sin } 2\theta / g + 1/4 V_o^2 \text{Sin} 2\theta / g$

$\theta = 26.6^o$

2cii $[2V_o \sin 26.6^o/g + V_o \sin 26.6^o/g] / 2V_o \sin 45^o/g = 0.949$

3a If there is no resultant external force acting on a system of bodies, the total linear momentum of the system always remain constant.

3bi Graph is force time graph on ball B by ball A. (Assuming right as positive)

Impulse delivered to ball B by ball A = area under F-t graph
= 0.5 $(12\text{x}10^{-3})8$
= 0.048 Ns

Impulse delivered to ball B by ball A = $0.1(v_f - 0)$
$0.048 = 0.15\, v_f$
$\underline{v_f = 0.32\ \text{ms}^{-1}}$

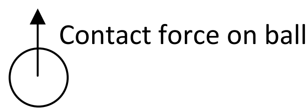
3bii - Newton's 3rd law says……..

- Force on B (due to A) is equal in magnitude and opposite in direction to force (due to B)

- time (of contact) (*t*) is same for both **AND** Impulse = *Ft*
- impulse on A is equal in magnitude and opposite in direction to impulse on B

3c Impulse on net by ball = $F_{\text{by ball}}$ (t)

By newton's 3rd law, force on net by ball = - Force on ball by net



During impact,
Force on ball by net = contact force on ball by net
= weight of ball + force to stop motion of ball, f_{stop}

Calculating v_i,
Using $v^2 = u^2 + 2as$ (taking downwards as positive)
$v_i = (2(9.81)(1))^{0.5}$
$= 4.43\ \text{ms}^{-1}$

Taking downwards as positive, where v_i is the speed of ball before it hits the net

$$f_{stop} = \frac{m}{t}(v_f - v_i)$$
$$= \frac{0.15}{0.5}(0 - v_i)$$
$$= \frac{0.15}{0.5}(0 - 4.43)$$
= 1.329 N, upwards

Force on net by ball = 0.15(9.81) + 1.329
= 2.8005 N, downwards

Impulse = 2.8005(0.5) = **<u>1.40 Ns, downwards</u>**

4ai Applying the Principle of Conservation of Energy on the energy of the ball:

Loss in elastic potential energy = Gain in kinetic energy + gain in gravitational potential energy

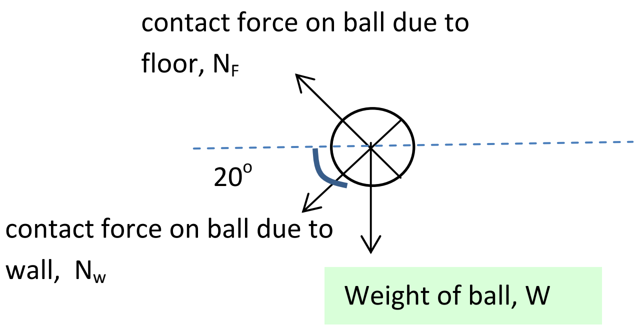
$\frac{1}{2}Fx = \frac{1}{2}mv^2 + mgh$

$\frac{1}{2}(6.15)(50\times10^{-3}) = \frac{1}{2}(0.050)v^2 + (0.050)(9.81)(50\times10^{-3} + 0.70)\sin 20^\circ$

$v = 1.057$
$= 1.06\ \text{ms}^{-1}$

[2]

4aii



[2]

4b For the ball to complete the circular motion, the centripetal force is provided by the contact force on ball due to wall and component of the weight that is directed to the centre of the circle.

Using Newton's 2nd law: $F_{net} = ma$

$N_w + W\sin20^\circ = mv^2/r$

$N_w = mv^2/r - W\sin20^\circ$

For circular motion to be completed, $N_w > 0$

$mv^2/r - W\sin20^\circ > 0$

$mv^2/r > mg\sin20^\circ$

$v > \sqrt{(rg\sin20^\circ)}$

$v > 1.003\ \text{ms}^{-1}$

Since the speed in (a)(i) is greater than the minimum speed required, the ball is able to complete the circular path.

5a Electrons are considered as particles when they undergo collision with other particles for example in the instance when an accelerated electron is used to excite an atom. When an electron undergo diffraction through a thin sheet of graphite, forming a diffraction pattern, it is considered as a wave.

5bi By conservation of energy,
Loss in electric potential energy = Gain in Kinetic energy of the electron,

$$40 \text{ eV} = \frac{1}{2} mv^2$$

horizontal speed of the electrons, v = $\sqrt{(2 \times 40 \times 1.6 \times 10^{-19} / 9.11 \times 10^{-31})}$
= 3.748×10^6
= 3.75×10^6 ms^{-1}

5bii Using De Broglie's relationship: $\lambda = h/p$

= $6.63 \times 10^{-34} / 9.11 \times 10^{-31} \times 3.748 \times 10^6$

= 0.1942 nm

$$\sin\theta = \frac{\lambda}{D} = 3.88 \times 10^{-5}$$

Now $\tan\theta = \frac{p_y}{p_x} \Rightarrow p_y = \left(3.4148 \times 10^{-24}\right)\left(3.88 \times 10^{-5}\right) = 1.32 \times 10^{-28}\, kgms^{-1}$

Therefore maximum y-component of the momentum of an electron = $1.32 \times 10^{-28}\, kgms^{-1}$

5biii $\Delta p_y \approx 1.32 \times 10^{-28}\, kgms^{-1}$

$$\Delta y\, \Delta p_y \geq \frac{\hbar}{2} \Rightarrow \Delta y \geq \frac{\hbar}{2\Delta p_y} \approx 3.98 \times 10^{-7}\, m$$

6a Rotational equilibrium, where the net torque at any point on the body is zero as well as translation equilibrium, where the net force on the body is zero must be achieved.

6bi Force arrow shown downwards at the edge of the slab.

Force shown upwards at C and weight acting downwards.

6bii 1 Taking moments about C,

350 x (1.80-0.55) = F x 0.55

F = 795 N

6bii 2 Taking moments about the edge of the slab,

Weight = 2F = 1590 N

6c Work = Force x displacement in the direction of Force

In a gravitational field,

Work done by mass = Force against gravitation field x displacement in the direction of Force

Gravitation potential energy = m g x h = mgh

6di GPE = 1.0×10^{10} (9.81) (370) = 3.63×10^{13} J = 4×10^{13} J (1sf)

6dii By conservation of Energy,

Loss in GPE = Gain in KE

$4 \times 10^{13} = ½ (1.0 \times 10^{10}) v^2$

$v = 89 \text{ ms}^{-1}$

6diii Energy = Pt

$t = (4 \times 10^{13}) / (4 \times 10^6) = 1 \times 10^5$ s = 27.8 hours

6e
- work done lost to friction in pumps/ generators/ turbine
- Energy lost in transmission due to current/resistance in wires → I^2R heating or collisions of electrons with lattice
- KE of water not reduced to zero in the generator. Not all KE converted to electrical energy.

7a When two or more waves meet at a point, the resultant displacement at that point is equal to the vector sum of the displacements due to the individual waves at that point.

7bi For observable stationary waves, the frequency of the oscillator needs to match the natural frequency of the wire which depends on the length of the vibrating wire and the tension in the wire. Hence it is usually necessary to adjust the components till they match.

7bii A node is a position along a standing wave where the amplitude of vibration is zero. When the wave reached the pulley, it is reflected from the pulley. The incident wave and the reflected wave are anti-phase and hence they superpose to form zero amplitude.

7biii wavelength = 0.16 x 2 = 0.32 m
The frequency of the oscillator will be the same as the frequency of the wave.
Speed = 0.32 x 75 = 24 ms^{-1}

7biv The magnet will form a magnetic field around the wire. As the current in the wire alternates in direction, there will be an alternating magnetic force set up due to the magnetic field, causing the middle of the set up to vibrate. The wave travels to both ends and get reflected. The incident wave and reflected wave are of the same frequency and similar amplitude and hence superpose to form stationary wave.

7ci1 X

7ci2 thermistor

7cii For X

- increased temperature increases the amplitude of lattice vibrations.
- Increases the rate of collision of electrons/ charge carriers with lattice

For Y more charge carriers available for conduction at higher temperature as the charge carriers gain sufficient energy to escape from the lattice.

7ciii1 26 ^{o}C

7ciii2 At 70^{o}C, R_x = 460 Ω R_y = 90 Ω
Hence Total resistance = 460 + 90 = 550 Ω
I = V/ R = 4.5 / 550 = 8.18 A

8ai When an electron is excited to a higher energy level due to the current which was passed through the gas, it quickly de-excites to a lower energy level, emitting a photon. The energy and hence wavelength of the photon depends on the difference in energy of the two energy levels the electrons transited from.

8aii1 E = hc/ λ
$E_{2.0}$ = 5.0 x 10^{-19} J = 3.11 eV
$E_{4.0}$ = 9.9 x 10^{-19} J = 6.22 eV

8aii2 Energy of level **B** = -1.5 x 10^{-18} J
Energy of level **C** = 1.0 x 10^{-18} J

8aiii Collision with the other atoms/ Collision with electrons/ heating thermally

8bi Resistance of component/ chemicals in the battery.
Some potential difference is used to move the charges through the internal resistance. In X there is no current hence no potential difference is lost. However in Y there is a current passing through it and hence potential difference is lost.

8bii V = E – Ir
3.1 = 4.5 – 0.39 r
r = 3.6 Ω
Hence internal resistance of a single cell = 3.6/ 3 = 1.2 Ω

8ci R_1/ R_2 = V_1 / V_2
4 =150/ (150+ R) x 6
R = 75 Ω

8cii $P = V^2 / R = 0.16$ W

8ciii 3.5 mm