Wallace Hall Academy

CfE Higher Physics

Our Dynamic Universe

Exam Questions Part 2: Solutions

O.D.U. Part II Examination Questions

Page 1

GRAVITATION

1 (a) (i) $v_H = v\cos\theta$

$\therefore v_H = 7{\cdot}0\cos 60°$

$\therefore v_H = 3{\cdot}5$ HORIZONTAL COMPONENT is $\underline{\underline{3{\cdot}5\ ms^{-1}}}$

(ii) $v_V = v\sin\theta$.

$\therefore v_V = 7{\cdot}0\sin 60°$

$\therefore v_V = 7{\cdot}0 \times 0{\cdot}866$

$\therefore v_V = 6{\cdot}062$ VERTICAL COMPONENT IS $\underline{\underline{6{\cdot}1\ ms^{-1}}}$

(b) HORIZ.

s_H, v_H, t $\quad s = v_H t$

$\therefore t = s_H / v_H$

$\therefore t = 2{\cdot}8 / 3{\cdot}5$

$\therefore t = 4/5 = 0{\cdot}8$ TIME TO DISH = $\underline{\underline{0{\cdot}8\ s}}$

(c) VERT

s ?
$u = 6{\cdot}062$
v ×
$a = -9{\cdot}8$
$t = 0{\cdot}8$

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

$\therefore s = 6{\cdot}062 \times 0{\cdot}8 - \frac{1}{2} \times 9{\cdot}8 \times 0{\cdot}8^2$

$\therefore s = 4{\cdot}8496 - 3{\cdot}136$

$\therefore s = 1{\cdot}7136$ HEIGHT IS $\underline{\underline{1{\cdot}7\,M}}$

(d) Since coin is at a higher point in the dish it has gained gravitational potential energy. As the total energy of the coin is constant after launch the K.E. at the dish is less than that at the start.

O.D.U. PART II Examination Questions

GRAVITATION.

2. (a)(i) $v_H = v\cos 40^\circ$

$\therefore v_H = 35.0 \times 0.766$

$\therefore v_H = 26.8116$ HORIZONTAL COMPONENT IS $\underline{\underline{26.8\ ms^{-1}}}$

(ii) $v_V = v\sin 40^\circ$

$\therefore v_V = 35.0 \times 0.6428$

$\therefore v_V = 22.4976$ VERTICAL COMPONENT IS $\underline{\underline{22.5\ ms^{-1}}}$

(iii) VERT

~~s~~

$u = 22.4976$
$a = -9.8$
$v = 0$
$t\ ?$

$v = u + at$

$\therefore 0 = 22.4976 - 9.8t$

$\therefore t = \dfrac{22.4976}{9.8}$

$\therefore t = 2.29567$ TIME TO TOP IS $\underline{\underline{2.3\ s}}$

(b) HORIZ (Range of symmetric part)

s_H
v_H
t

$s_H = v_H t$

$\therefore s_H = 26.8116 \times 2.29567 \times 2$

$\therefore s_H = 123.10$

HORIZ. (Extra distance to R)

s_H
v_H
t

$s_H = v_H t$

$\therefore s_H = 26.8 \times 0.48$

$\therefore s_H = 12.8696$

Total horizontal distance is $\underline{\underline{136\ m}}$.

GRAVITATION

3 (a)(i) $v_H = v\cos\theta$.

$\therefore v_H = 6.5 \times \cos 50^\circ$

$\therefore v_H = 6.5 \times 0.64279$

$\therefore v_H = 4.178$ HORIZONTAL COMPONENT IS $\underline{\underline{4.2\,ms^{-1}}}$

(ii) $v_V = v\sin\theta$.

$\therefore v_V = 6.5\sin 50^\circ$

$\therefore v_V = 6.5 \times 0.766$

$\therefore v_V = 4.9793$ VERTICAL COMPONENT IS $\underline{\underline{4.98\,ms^{-1}}}$ ($5.0\,ms^{-1}$)

(b) HORIZ

s_H
v_H
t

$s_H = v_H t$.

$\therefore t = s_H / v_H$

$\therefore t = \frac{2.9}{4.2}$

$\therefore t = 0.69$ TIME TO BASKET = $\underline{\underline{0.69\,s.}}$

(c) VERT (Height of throw)

s ?
$u = 4.98$
v ×
$a = -9.8$
$t = 0.69$

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

$\therefore s = 4.98 \times 0.69 - \frac{1}{2} \times 9.8 \times 0.69^2$

$\therefore s = 3.4357 - 2.33289$

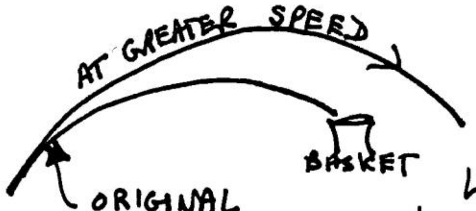
$\therefore s = 1.10281$

Height of top of basket = $h = s_1 + s_2$

$= 1.10281 + 2.3$

$= \underline{\underline{3.4\text{ m}}}.$

(d)



Launched at the same angle at a greater speed would increase both velocity components. This would increase maximum height reached and increase the horizontal distance to max height, shifting the peak of the trajectory to the right causing ball to fly over basket as shown

O.D.U. Exam Questions Part II.

GRAVITATION

4 (a) $v_V = v\sin\theta$

$\therefore v_V = 14 \sin 30°$

$\therefore v_V = 7$ Vertical component is $\underline{\underline{7 ms^{-1}}}$

(b) The maximum height reached is increased as θ is increased because the vertical component $v\sin\theta$ is increasing v = constant, $\sin\theta \uparrow$

5

HORIZ.

$s = vt$

$\therefore t = s/v$

$\therefore t = 30/100$

$\therefore t = 0.3$

VERT.

$s = d = ?$

$u = 0$

v ×

$a = -9.8$

$t = 0.3$

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

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

$\therefore d = 0 + (\frac{1}{2} \times -9.8 \times 0.3^2)$

$\therefore d = -4.9 \times 0.09$

$\therefore d = -0.441$

Bottom of target is $1.5 - 0.9 = 0.6$ m below firing level

As arrow only drops 0.441 m.

Hence arrow hits target.

6 (a)(i) $v_H = v\cos\theta$.

$\therefore v_H = 41.7 \times \cos 36°$

$\therefore v_H = 33.7$ Horizontal component is $\underline{\underline{33.7 ms^{-1}}}$

(ii) $v_V = v\sin\theta$.

$\therefore v_V = 41.7 \times \sin 36°$

$\therefore v_V = 24.5$ Vertical component is $\underline{\underline{24.5 ms^{-1}}}$

(b) Max height reached. (vert)

$s = ?$

$u = 24.5$

$v = 0$

$a = -9.8$

t = ×

$v^2 = u^2 + 2as$

$\therefore 0 = 24.5^2 - 2 \times 9.8 \times S$

$\therefore 19.6S = 600.25$

$\therefore S = 30.625$

Max height is 30.63 m

(b) Time to P (Vertical)

s
$u = 24.5$
$v = 0$
$a = -9.8$
$t = ?$

$v = u + at$
$\therefore 0 = 24.5 - 9.8t$
$\therefore 9.8t = 24.5$
$\therefore t = 2.5$

Time P to Q (Vertical)

$s = -19.6$
$u = 0$
$v \times$
$a = -9.8$
$t = ?$

$s = ut + \frac{1}{2}at^2$
$\therefore s = \frac{1}{2}at^2$
$\therefore -19.6 = -4.9t^2$
$\therefore t^2 = 4$
$\therefore t = 2$

Total time till Q $= 2.5 + 2.0$
$= \underline{\underline{4.5\ s}}$

(c) HORIZONTAL

$s = ?$
$v = 33.7$
$t = 4.5$

$s = vt$
$\therefore s = 33.7 \times 4.5$
$\therefore s = 151.65$

Horizontal distance $= \underline{\underline{152\ m}}$

4 (a)(i) VERT

$s = 0.86$
$u = ?$
$v = 0$
$a = -9.8$
t

$v^2 = u^2 + 2as$
$\therefore 0 = u^2 - 2 \times 9.8 s$
$\therefore 0 = u^2 - 19.6 \times 0.86$
$\therefore 0 = u^2 - 16.856$
$\therefore u = 4.106$

Initial velocity is $\underline{\underline{4.1\ ms^{-1}}}$

(ii) Time of flight. VERT

$s = 0$
$u = 4.1$
$v = -4.1$
$a = -9.8$
$t = ?$

$v = u + at$
$\therefore -4.1 = 4.1 - 9.8t$
$\therefore -8.2 = -9.8t$
$\therefore t = 0.83\dot{7}$

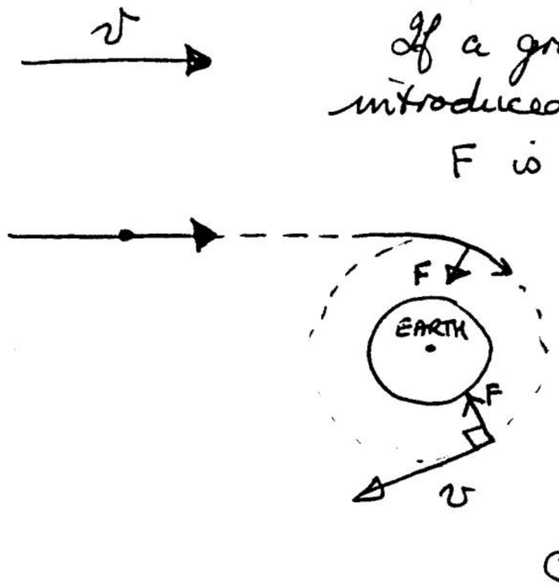
HORIZ

$s = v_H t$
$\therefore v_H = s/t$
$\therefore v_H = 7.8/0.837$
$\therefore v_H = 9.32$

Horizontal component is $\underline{\underline{9.32\ ms^{-1}}}$

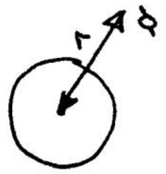
(b) Assuming that the energy of the jump is the same then as he gains less gravitational P.E. he must have more KE so his horizontal motion must involve a greater value of velocity.

8 (a) The natural motion for any body not acted on by any unbalanced force is constant velocity



If a gravitational force is introduced from a planet as shown F is an unbalanced force causing the body to accelerate ie change its velocity. As the force is perpendicular to the velocity it keeps changing the direction of v and maintains a circular path.

(b)



$$r = R_E + h.$$
$$= 6.4\times10^6 + 400\times10^3$$
$$= 6.4\times10^6 + 0.4\times10^6$$
$$= 6.8\times10^6$$

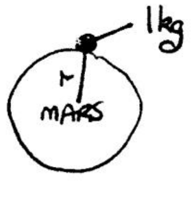
$$F_{grav} = \frac{Gm_1m_2}{r^2}$$

$$\therefore F_{grav} = \frac{6.67\times10^{-11}\times6.0\times10^{24}\times900}{(6.8\times10^6)^2}$$

$$\therefore F_{grav} = 7.79\times10^3$$ Gravitational force is $\underline{\underline{7.79\times10^3\,N}}$

9 (a)(i) Gravitational field strength is the weight per unit mass or force per unit mass.

(ii)



Since g = gravitational field strength $= F/m$

$\therefore$ force on the 1kg $= g = 3.7$

$$F_{grav} = \frac{GM_m\times1}{r^2} = g.$$

$$\therefore M_m = \frac{gr^2}{G}$$

9 (a)(ii)(B) $M = \frac{gr^2}{G}$.

$\therefore M = \frac{3.7 \times (3.4 \times 10^3 \times 10^3)^2}{6.67 \times 10^{-11}}$

$\therefore m = 6.43 \times 10^{23}$ Mass of Mars = 6.43×10^{23} kg

(b)

$r = R + h$

$\therefore r = 3.4 \times 10^6 + 3 \times 10^5$

$\therefore r = 3.4 \times 10^6 + 0.3 \times 10^6$

$\therefore r = 3.7 \times 10^6$

$F_{grav} = \frac{G M_m M_s}{r^2}$

$\therefore F_{grav} = \frac{6.67 \times 10^{-11} \times 6.43 \times 10^{23} \times 100}{(3.7 \times 10^6)^2}$

$\therefore F_{grav} = 313$. Force exerted by Mars is 313N

O.D.U. EXAM QUEST. II. Special Relativity

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1. (a)

$$t = \frac{t_0'}{\sqrt{1 - v^2/c^2}} \qquad t_0 = 8.2 \times 10^{-7}\,s.$$

$$\therefore t = \frac{8.2 \times 10^{-7}}{\sqrt{1 - \left(2 \times 10^8 / 3 \times 10^8\right)^2}}$$

$$\therefore t = \frac{8.2 \times 10^{-7}}{\sqrt{1 - 4/9}}$$

$$\therefore t = \frac{8.2 \times 10^{-7}}{\sqrt{5/9}}$$

$$\therefore t = \frac{8.2 \times 10^{-7}}{\sqrt{5}/\sqrt{9}}$$

$$\therefore t = \frac{3 \times 8.2 \times 10^{-7}}{\sqrt{5}}$$

$$\therefore t = \frac{24.6 \times 10^{-7}}{\sqrt{5}}$$

$$\therefore t = 1.1 \times 10^{-6}$$

Half life is $\underline{\underline{1.1\,\mu s}}$

(b) distance = speed × time

$$= 2.0 \times 10^8 \times 1.1 \times 10^{-6}$$

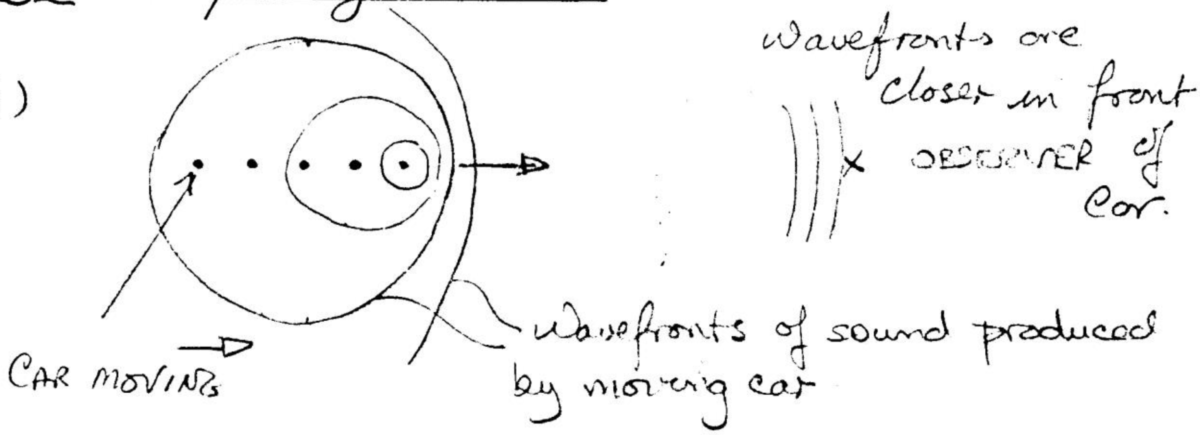
$$= 2.2 \times 10^2$$

Distance travelled is $\underline{\underline{220\,m}}$

O.D.U. Examination Questions II

PAGE 10/11 Expanding Universe.

1 (a)(i)



Observer hears a sound of higher frequency than that emitted by source.

(ii) $f_o = \left(\frac{v}{v \pm v_s}\right) f$

$\therefore f_o = \left(\frac{v}{v - v_s}\right) f$ for approaching car.

$\therefore f_o = \left(\frac{340}{340 - 25}\right) 1250$

$\therefore f_o = \left(\frac{340}{315}\right) \times 1250$

$\therefore f_o = 1349$

Observed frequency is <u>1350 Hz</u>

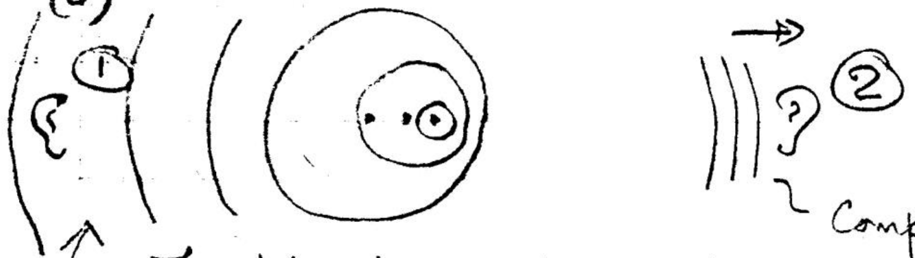
(b) The spectrum from the star has lines which are shifted to a longer wavelength. Hence the frequency is lessened. Hence distance star is moving away from the observer.

O.D.U. Examination Questions II

THE EXPANDING UNIVERSE.

2. (a) As the train approaches the observed frequency is greater than the actual frequency and as the train recedes the frequency is less than the actual frequency. The wavefronts on the approach are compressed making f greater and are stretched further apart as train recedes.

(b)



The dots show subsequent positions of moving source.

Compressed wavefronts passing ear make observed frequency greater for observer 2

Wavefronts are stretched out behind the receding source making the observed frequency less for this observer.

(c) $f_o = \left(\frac{v}{v \pm v_s}\right) f$

$\therefore\ 760 = \left(\frac{340}{340 + v_s}\right) 800$

$\therefore\ 340/(340+v_s) = 76\cancel{0}/80\cancel{0} = 0.95$

$\therefore\ 340 = 0.95(340 + v_s)$

$\therefore\ 340 = 323 + 0.95 v_s$

$\therefore\ 0.95 v_s = 340 - 323$

$\therefore\ 0.95 v_s = 17$

$\therefore\ v_s = 17/0.95$

$\therefore\ v_s = 17.89$ The speed of the train is $\underline{17.9\,ms^{-1}}$

3 (a)
$$f_o = \left(\frac{v}{v \pm v_s}\right) f_s .$$
$$\therefore f_o = \left(\frac{v}{v + v_s}\right) f_s$$
$$\therefore f_o = \left(\frac{340}{340 + 30}\right) \times 300$$
$$\therefore f_o = \left(340/370\right) \times 300$$
$$\therefore f_o = 0.9189 \times 300$$
$$\therefore f_o = 276$$
Obsesved frequency = 276 Hz

(b) The galaxy is moving away from the Earth because the frequency is lowered and hence the wavelength is increased so the visible wavelengths are shifted to the red end of the spectrum.

4 (a)
$$v_r = H_o d .$$
$$\therefore d = v_r / H_o$$
$$\therefore d = \frac{5.5 \times 10^6}{2.4 \times 10^{-18}}$$
$$\therefore d = 2.2917 \times 10^{24}$$
Distance to galaxy = 2.29×10^{24} m

(b) The wavelength of the radiation can be measured and indicates the temperature T.

5 (a) Distant Stars & Galaxies are moving away from the Earth at speed. This causes the light spectrum from these sources to be shifted to longer wavelengths or lower frequencies making them appear "redder". This is the redshift. As almost all distant objects show this, it is evidence that the Universe is expanding.

(b)(i) Dark Matter is theoretical material, invisible, that is used to account for the extra force not provided by gravity, that is needed to explain the fastest moving stars in spiral galaxy arms remaining in orbit around the galactic centre.

5.(b) (ii) With sufficient "dark matter" the mass of the Universe would be great enough to slow down the expansion so that the Universe is "CLOSED". Without sufficient "dark matter" the mass of the Universe is too small to expect gravity to hold it together and it will expand for ever resulting in an "open" Universe.

6.(a)(i) ① $v_r/d = \frac{2.0\times10^5}{9.0\times10^5} = 0.222$

② $v_r/d = \frac{2.2\times10^6}{2.3\times10^7} = 0.0956$

③ $v_r/d = \frac{2.3\times10^7}{1.4\times10^8} = 0.164$

(ii) $v_r - H_0 d$ $d = 1.4\times10^8\ ly$

$\therefore d = 1.4\times10^8 \times 3.0\times10^8 \times 365.25\times24\times60\times60$

$\therefore d = 1.325\times10^{24}$

$H_0 = v_r/d = \frac{2.3\times10^7}{1.325\times10^{24}}$

$= \underline{\underline{1.74\times10^{-17}\ s^{-1}}}$

(iii) This value is slightly higher than the $2.4\times10^{-18}s^{-1}$ accepted today. Initially the no of galaxies in the sample was quite small.

(b) (i) Redshift is the relative wavelength change in spectral lines observed in light from distant stars & galaxies

Redshift $= Z = \left(\frac{\lambda - \lambda_0}{\lambda_0}\right)$

(ii) Galaxies nearer the edge of the observable universe have greater redshifts because those galaxies have travelled the farthest because they were moving the fastest

ODU EXAM QUESTIONS II BIG BANG THEORY

1. (a) $T\lambda_{peak} = 4200 \times 6.90 \times 10^{-7} = 2.898 \times 10^{-3}$

$5800 \times 5.00 \times 10^{-7} = 2.90 \times 10^{-3}$

$7900 \times 3.65 \times 10^{-7} = 2.8835 \times 10^{-3}$

$12000 \times 2.42 \times 10^{-7} = 2.904 \times 10^{-3}$

= constant of 2.9×10^{-3}

$\Rightarrow T\lambda_{peak} = 2.9 \times 10^{-3} \Rightarrow T = \dfrac{2.9 \times 10^{-3}}{\lambda_{peak}}$.

(b) $T = \dfrac{2.9 \times 10^{-3}}{76 \times 10^{-9}} = 3.8 \times 10^{4}\ K$

(c) (i) Cosmic microwave background radiation

(ii) The CMBR is the radiation remnant from the Big Bang which has the characteristics of blackbody radiation cooled to 3K due to expansion of the universe uniformly in all directions

ODU EXAM QUESTIONS II BIG BANG THEORY

2. (a)

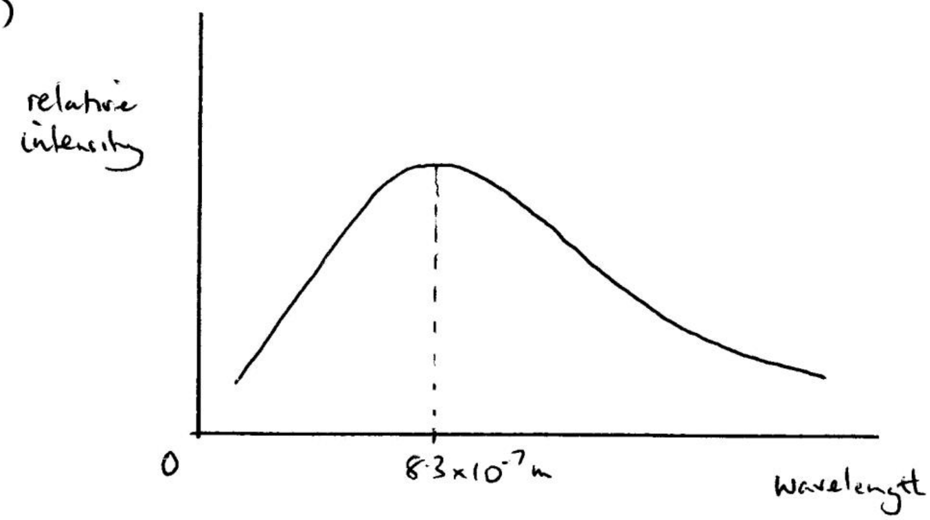
$$T = \frac{2.9 \times 10^{-3}}{\lambda_{peak}}$$

$$3500 = \frac{2.9 \times 10^{-3}}{\lambda_{peak}}$$

$$\lambda_{peak} = \frac{2.9 \times 10^{-3}}{3500}$$

$$= 8.3 \times 10^{-7}\ m$$

(b)



1. (a)(i) $\bar{t} = \sum_{i=1}^{6} t_i / 6$.

$\therefore \bar{t} = 0.096/6$

$\therefore \bar{t} = 0.016$ Mean time is $0.016\ s$.

(ii) $\Delta u = \frac{t_{max} - t_{min}}{n}$

$\therefore \Delta u = \frac{0.019 - 0.013}{6}$

$\therefore \Delta u = 0.006/6$

$\therefore \Delta u = 0.001$ Absolute random uncertainty $= \pm 0.001 s$

(b) $u = 0$; $v = \frac{\text{mask length}}{\text{mean time}}$

$\therefore v = 0.020/0.016$

$\therefore v = 1.25$

$s = 0.60m$
$u = 0$
$v = 1.25 ms^{-1}$
$a = ?$
t ×

$v^2 = u^2 + 2as$

$\therefore v^2 = 2as$

$\therefore 1.25^2 = 2 \times 0.6 \times a$.

$\therefore a = 1.25^2 / 1.2$

$\therefore a = 1.30208$ Acc'n is $1.3\ ms^{-2}$

2. (a)(i) Loss in grav. P.E = gain in K.E.

$\therefore mgh = \frac{1}{2}mv^2$

$\therefore gh = v^2/2$

$\therefore v^2 = 2gh$

$\therefore v = \sqrt{2gh}$

$\therefore v = \sqrt{2 \times 9.8 \times 3.15}$

$\therefore v = \sqrt{61.74}$

$\therefore v = 7.8575$ Speed of ball is $\underline{\underline{7.86\ ms^{-1}}}$

OR

Equation of Motion can be used

(ii) loss in K.E. = gain in grav. P.E.

$\therefore \frac{1}{2}mv^2 = mgh.$

$\therefore v^2 = 2gh.$

$\therefore v = \sqrt{2gh}$

$\therefore v = \sqrt{2 \times 9.8 \times 1.75}$

$\therefore v = \sqrt{34.3}$

$\therefore v = 5.8566.$ Speed of ball is $\underline{\underline{5.86\ ms^{-1}}}$

(b)(i) $\bar{h} = \sum_{i=1}^{6} h_i / 6.$

$\therefore \bar{h} = 10.44/6$

$\therefore \bar{h} = 1.74$ Mean height is $\underline{\underline{1.74\ m}}$

(ii) $\Delta U = \dfrac{h_{max} - h_{min}}{n}.$

$\therefore \Delta u = \dfrac{1.78 - 1.71}{6}$

$\therefore \Delta u = 0.01167$

Random uncertainty is $\pm \underline{\underline{0.012}}\ m$

3 (a)(i)(A) $\bar{t} = \sum_{i=1}^{5} t_i / 5$

$\therefore \bar{t} = 1275/5$

$\therefore \bar{t} = 255$ Mean time is $\underline{255\,\mu S}$.

(B) $\Delta U = \dfrac{t_{max} - t_{min}}{5}$

$\therefore \Delta U = \dfrac{263 - 248}{5}$

$\therefore \Delta U = 15/5$

$\therefore \Delta U = 3.$ Absolute random uncertainty $= \underline{\pm 3\,\mu S}$

(ii) Max value of $\bar{t}$ is $(255 + 3)\,\mu S$

$= 258\,\mu S.$

Club does NOT meet the standard as $258\,\mu s$ is greater than $257\,\mu S$.

(b)(i) $\bar{F}\Delta t = \Delta(mv)$

$\therefore \bar{F}\Delta t = m\Delta v$ (m - constant)

$\therefore \bar{F} \times 450 \times 10^{-6} = 4.5 \times 10^{-2} \times 50.0$

$\therefore \bar{F} = \dfrac{2.25}{450 \times 10^{-6}}$

$\therefore \bar{F} = 5000$ Average force is $\underline{5.0 \times 10^{3}\,N}$

(ii) $\bar{F}$ - same
m - Same

$\therefore$ using $\bar{F}\Delta t = \Delta(mv)$ if Δt is larger then $\Delta(mv)$ is larger so Δv is larger as m is constant so velocity is greater.

Pages 20/21   O.D.U. Exam Questions II   uncertainty

4. (a)(i) Distance is 0.2 m (graph intercept)

(ii) It falls 1.6 m (height of parabolic part)

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

$s = 1.6\ m$, $u = 0$, $v\ \times$, $a = ?$, $t = 0.6\ s$

$\therefore 1.6 = 0 + \frac{1}{2}a \times 0.6^2$

$\therefore 1.6 = 0.18a$

$\therefore a = 1.6/0.18$

$\therefore a = 8.8888$ Acc'n is $8.9\ ms^{-2}$

(b)(i) $\bar{a} = \sum_{i=1}^{5} a_i / 5$

$\therefore \bar{a} = 120.4/5$

$\therefore \bar{a} = 24.08$ Mean acc'n is $24.08\ ms^{-2}$

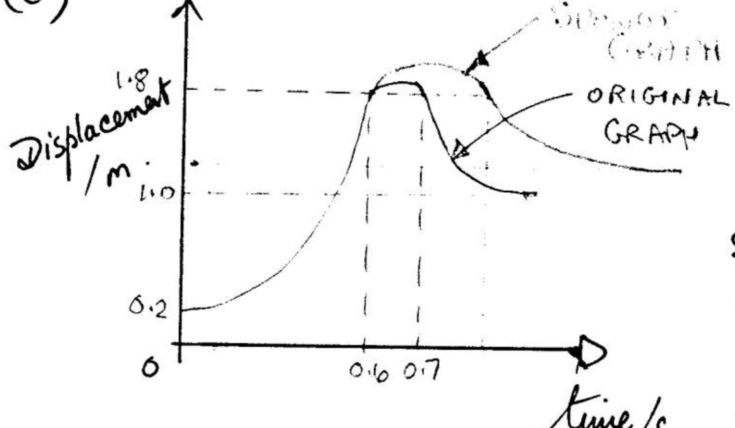
(ii) $\Delta u = \dfrac{a_{max} - a_{min}}{5}$

$\therefore \Delta u = \dfrac{9.1 - 8.5}{5}$

$\therefore \Delta u = 0.6/5$

$\therefore \Delta u = 0.12$ Random uncertainty $= \pm 0.12\ ms^{-2}$

(c)



The contact time with the sponge is greater and the basket ball goes further down into the sponge before coming to rest and the basket ball rises to a lesser height as more energy is "lost" at the bounce.

5. (a)(ii) $\bar{F}\Delta t = \Delta(mv)$

$\therefore \bar{F} \times 0.005 = 0.045\left(\frac{24\times10^{-3}}{0.06}\right)$

$\therefore \bar{F} \times 0.005 = 0.018$

$\therefore \bar{F} = 3.6$

(i) $v = s/t$

$\therefore v = \frac{24\times10^{-3}}{0.06}$

$\therefore v = 0.4$

Speed of ball is $0.4\ ms^{-1}$

Average force is $3.6N$

(b)(i) Mass % error $= \frac{0.01}{45} \times \frac{100}{1} = 0.022\%$

Time of Contact % error $= \frac{0.001}{0.005} \times \frac{100}{1} = 20\%$

Time through gate % error $= \frac{1}{60} \times \frac{100}{1} = 1.7\%$

Ball diameter % error $= \frac{1}{24} \times \frac{100}{1} = 4.2\%$

Largest contribution from Time of Contact

(ii) 20% of 3.6N is 0.72 N.

$\therefore$ Average force is $(3.6 \pm 0.7)N$

use 1 sig. fig. unless the first digit is a '1'