Heery's Zen Notes

Physics KSSM F4 2021

Chapter 3:

KEGRAVITIAN – BAH.1 *(GRAVITATION – PART 1)*

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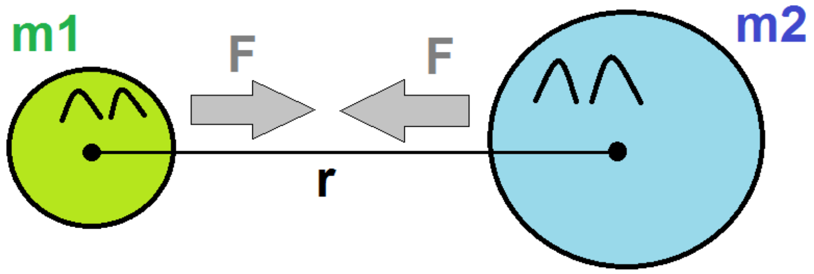
A. HUKUM KEGRAVITIAN SEMESTA NEWTON (NEWTON'S UNIVERSAL LAW OF GRAVITATION)

1. Untuk 2 jasad di angkasa, **daya graviti, F** *(For 2 bodies in space,* ***gravitational force, F****)*

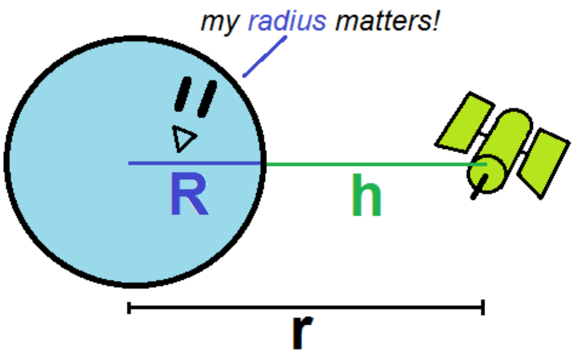


$$F = \frac{G\,m1m2}{r^2}$$

2. Hukum mengatakan bahawa *(The law stated that):*

Daya adalah berkadar terus dgn hasil darab jisim jasad *Force is directly proportional with the product of bodies' mass*
Daya adalah berkadar songsang dgn kuasa dua jarak jasad *Force is inversely proportional to the square two distance*

3. Jgn lupa! Jarak r hendaklah mengambil kira **jejari jasad (R)** *(Don't forget! Distance r should include the* ***radius of body (R)****)*



CONTOH SOALAN 1:

Kira daya graviti yg bertindak ke atas satelit pada altitud 20,000 km
Calculate the gravitational force exerted on satellite at altitude 20,000 km

Jisim satelit, m = 8000kg
Jisim Bumi, M = 5.9 x 10^{24} kg
Jejari Bumi, R = 6.37 x 10^{6} m
G = 6.67 x 10^{-11} Nm^2kg^{-2}

Dlm pengiraan, pastikan semua guna unit SI!
(In calculation, make sure all use SI unit!)

Altitud 20,000km → **20x10⁶m**

$$F = \frac{GMm}{(R+h)^2}$$

$$= \frac{6.67\times10^{-11} \times 5.9\times10^{24} \times 8000}{(6.37\times10^{6} + 20\times10^{6})^2}$$

$$= 4527 \text{ N}$$

4. Bagaimana pula dgn pecutan graviti, g?/ How about gravity acceleration, g?

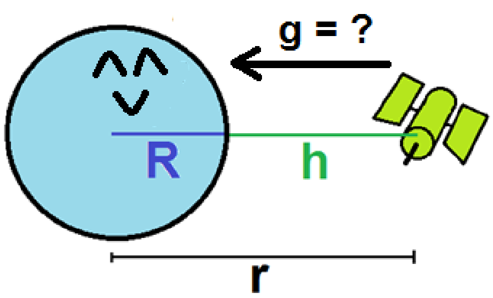
$F = \frac{GMm}{r^2}$	$g = \frac{GM}{r^2}$
$mg = \frac{GMm}{r^2}$	$g = \frac{GM}{r^2}$
$\cancel{m}g = \frac{GM\cancel{m}}{r^2}$	

Kesimpulannya/ *In conclusion:*

Pecutan graviti, g pada satu objek yg pada jasad dgn jisim M adalah <u>berkadar songsang</u> dgn kuasa dua jarak mereka

Gravitational acceleration, g of an object which on a body with mass M is <u>inversely proportional</u> to the square two of distance

Jom tengok contoh soalan 2 / *Let's observe this question example 2:*

<table>
<tr>
<td rowspan="2">

Jisim satelit, m = 8000kg
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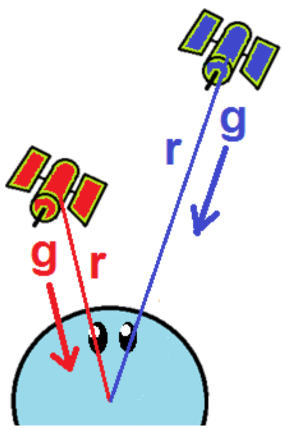
<td>Kira pecutan graviti yg bertindak ke atas satelit pada altitud 20,000 km
Calculate the gravity acceleration exerted on satellite at altitude 20,000 km</td>
</tr>
<tr>
<td>$g = \frac{GM}{(R + h)^2}$

$= \frac{6.67\times10^{-11} \times 5.9\times10^{24}}{(6.37\times10^{6} + 20\times10^{6})^2}$

$= 0.57ms^{-2}$</td>
</tr>
<tr>
<td colspan="2">Nilai pecutan g $0.57ms^{-2}$ adalah rendah krn satelit <u>jauh drpd Bumi</u>

Acceleration value $0.57ms^{-2}$ is low because satellite is <u>far from Earth</u></td>
</tr>
</table>

5. Untuk bandingkan g pada ketinggian berbeza, kita boleh guna formula GM *(To compare g at different height, we use GM formula)*



$$g = \frac{GM}{r^2}$$

$$GM = gr^2$$

Objek mempunyai GM yg sama pada altitud berbeza, maka
(*Objects have the same GM at different altitude, so*)

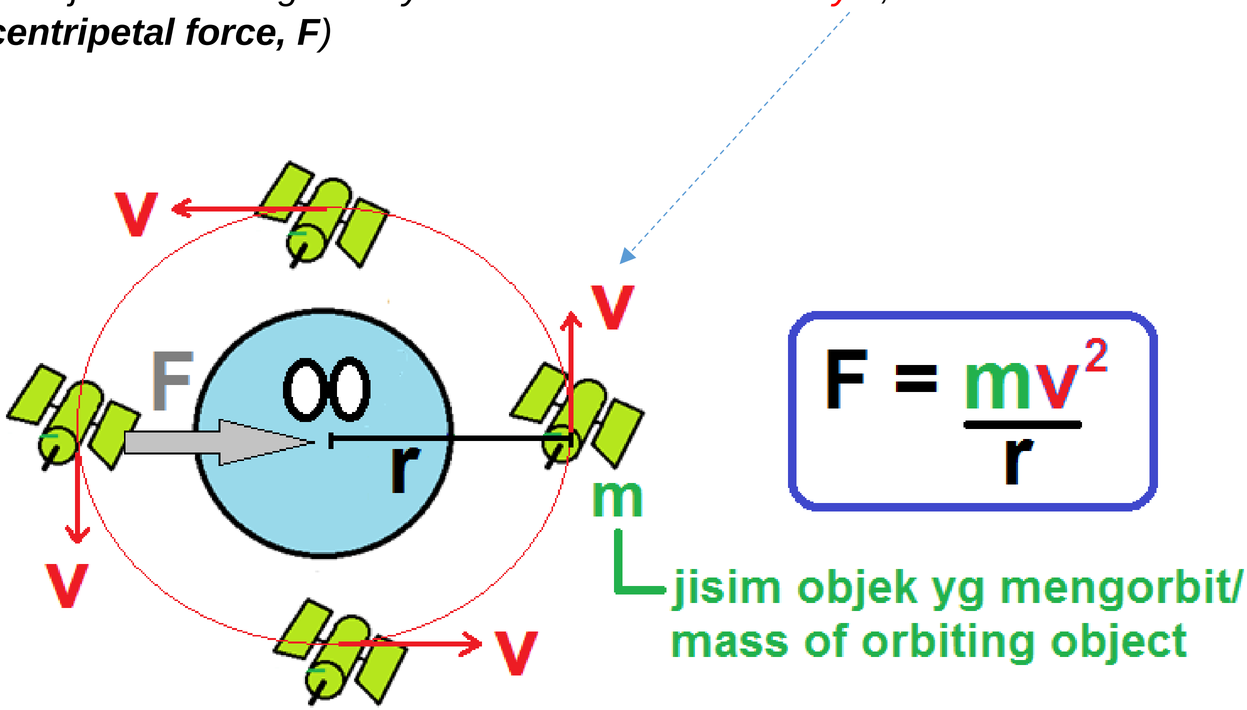
$$GM = GM$$
$$gr^2 = gr^2$$

CONTOH SOALAN 3:

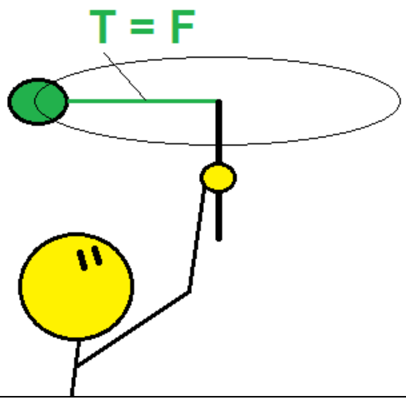
 Jejari Bumi, R = 6.37×10^6 m	Satelit pada altitud 15,000km mempunyai nilai g $3ms^{-2}$. Satelit menuruni altitud sebanyak 5000km. Kirakan nilai g yg baru *Satellite at 10,000km altitude has g value of $3ms^{-2}$. Satellite conducts 5000km descent. Calculate its new g.*
	Altitud baru = 15,000km – 5000km = 10,000km **$gr^2 = gr^2$** $g\,(R+h)^2 = g\,(R+h)^2$ $3\,(6.37x10^6 + 15x10^6)^2 = g\,(6.37x10^6 + 10x10^6)^2$ $g = 5.11ms^{-2}$

6. Jika objek mengorbit jasad pada halaju linear seragam v, kita boleh guna **daya memusat, F**

*(If object is orbiting a body at constant linear velocity v, we can use **centripetal force, F**)*



7. Eksperimen utk mengkaji daya memusat/ *Exp. to study the centripetal force:*

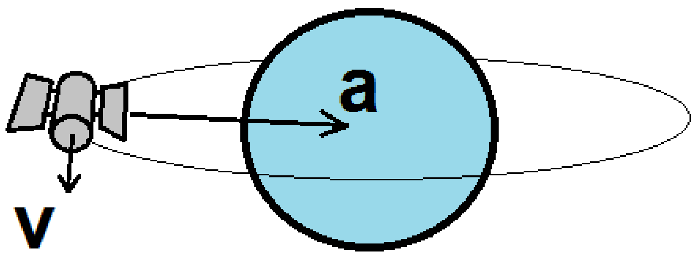
	Ketegangan tali T = Daya memusat F *(Rope tension T = Centripetal force F)* $$F = \frac{mv^2}{r}$$
Semakin besar ketegangan tali T, semakin laju bola bergerak v (apabila jisim bola m & panjang tali r adalah malar) *The larger the rope tension T, the faster the ball moving v (when ball mass m & rope length r are constant)*	

8. Bagaimana pula dgn pecutan memusat, a?/ *How about centripetal acceleration, a?*

$$F = \frac{mv^2}{r}$$ $$ma = \frac{mv^2}{r}$$	$$\cancel{m}a = \frac{\cancel{m}v^2}{r}$$ $$\boxed{a = \frac{v^2}{r}}$$

CONTOH SOALAN 4:

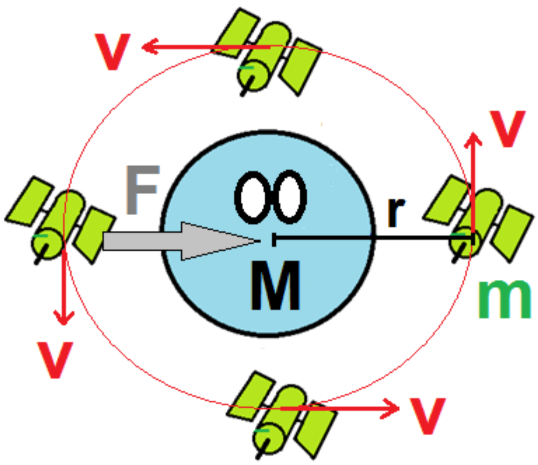
Satu satelit mengorbit Bumi dengan pecutan memusat **a = 4ms^{-2}** dan halaju linear **v = 7000ms^{-1}**. Kirakan altitud satelit tersebut *A satellite orbiting the Earth with centripetal acceleration **a = 4ms^{-2}** and linear velocity **v = 7000ms^{-1}**. Calculate its altitude.*



$a = \frac{v^2}{r}$ $4 = \frac{7000^2}{r}$ $r = 1.225 \times 10^7 m$	Altitude, h $r = R + h$ $h = r - R$ $= (1.225 \times 10^7 m) - (6.37 \times 10^6 m)$ $= 5.88 \times 10^6 \text{ m}$

9. Utk mengkaji hubungan antara halaju linear v dan jarak r, kita boleh gabungkan formula daya graviti dan daya memusat

(To find out the relationship between linear velocity v and distance r, we can combine gravitational force and centripetal force formula)



Gravity force = Centripetal force

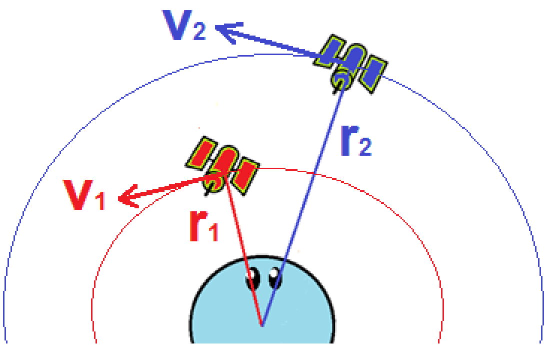
$$\frac{GMm}{r^2} = \frac{mv^2}{r}$$

$$\frac{GM\cancel{m}}{r^{\cancel{2}}} = \frac{\cancel{m}v^2}{\cancel{r}}$$

$$\boxed{GM = v^2 r}$$

*Guna GM=v^2r utk bandingkan halaju linear v pada altitud berbeza
Use GM=v^2r to compare linear velocity v at different altitude

CONTOH SOALAN 5:



Satelit pada altitud 408km mengorbit Bumi pada halaju linear 7000ms-1. Jika satelit tersebut berada pada altitud 1000km, kirakan halaju linear yg baru

A satellite at altitude 408km orbiting the Earth at linear velovity of 7000ms-1. If the satellite is at altitude 1000km, calculate its new linear velocity

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Tidak kira altitud atau halaju linear, objek masih <u>mempunyai GM sama</u>
Regardless of altitude or linear velocity, object still <u>has the same GM</u>

$$GM = GM$$
$$v^2 r = v^2 r$$
$$7000^2 \times (R + 4.08\times10^5) = v^2 \times (R + 1\times10^6)$$
$$7000^2 \times (6.37 \times 10^6 + 4.08\times10^5) = v^2 \times (6.37 \times 10^6 + 1\times10^6)$$

$$V = 6712 ms^{-1}$$

Kesimpulan/ *Conclusion:*

Guna **GM = gr²** utk bandingkan <u>pecutan graviti</u> pd ketinggian berbeza *Use **GM = gr²** to compare <u>gravity acceleration</u> at different height/altitude*
Guna **GM = v²r** utk bandingkan <u>halaju linear</u> v pada altitud berbeza *Use **GM = v²r** to compare <u>linear velocity</u> at different height/ altitude*