Scientist Of Utopia

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29 February 2024

1 Solution 1

Assumed Earth's gravity:

$$g_e(t,r) = \frac{GM_e}{r^2} + A\cos(\omega t)$$

Assumed Black Hole's gravity:

$$g_b(t,r) = \frac{GM_b}{r_s^2} + B\cos(\alpha t)$$

Here,

$M_e =$ Mass of Earth
$r =$ Radius of Earth
$A =$ Amplitude
$\omega =$ Angular Frequency (rate at which Earth completes one full rotation about axis)

Part a. Factors causing unexpected outcomes in data:

- The total mass of the black hole is not just the mass of the black hole itself but also includes the mass of the engulfed star. As the mass of the engulfed star is not mentioned, inaccurate values are obtained.
- Schwarzschild Radius may change: The Schwarzschild radius of the black hole would change with the additional mass of the engulfed star, which affects the gravitational field strength.
- Other minor factors include:
  - Heavy changes in the density of Earth's crust and mantle.
  - Heavy vibrational and electromagnetic forces that can cause changes in gravity.

Part b. Correct equation for the black hole:

Radius of star will be negligible comparing to r_s. So we are considering $r_s$as total radius.

$$g_b = \frac{G(M_b + M_s)}{r_s^2} + B\cos(\alpha t)$$

According to Newton's law:

$$F = mg$$

So now, using the above law:

$$\frac{GM_bM_s}{r_s^2} = (M_b + M_s)\left(\frac{G(M_b + M_s)}{r_s^2} + B\cos(\alpha t)\right)$$

Given:

$$G = 6.674 \times 10^{-11}\,\mathrm{m^3\,kg^{-1}\,s^{-2}}$$
$$M_b = 4 \times 10^{33}\,\mathrm{kg}$$

The gravitational field strength of the black hole can be expressed as:

$$g_b = \frac{6.674 \times 10^{-11}(4 \times 10^{33} + M_s)}{r_s^2} + B\cos(\alpha t)$$

Here, M_s is the mass of the engulfed star, which needs to be determined based on observational data.

2 Solution 2

This represents the solution addressing the second problem statement.

2.1 Solar Rings

Basic overview : Creating an artificial sun ring around earth containing compressed hydrogen gas and by providing continuous energy from black hole.

ABOUT RING: This structure could potentially serve as a source of energy generation through nuclear fusion, similar to the processes that power stars like our Sun. This ring would need to be made of materials capable of withstanding the harsh conditions of space, including extreme temperatures, radiation, and micro-meteoroid impacts.

Hydrogen: Extracting hydrogen from space involves capturing and collecting it from various sources such as the solar wind, interstellar medium, or other celestial bodies. Or currently, we can use primary terrestrial sources of hydrogen such as natural gas and electrolysis of water and develop advanced spacecraft capable of carrying large payloads of hydrogen from Earth to the ring structure in space.

Why Rings?:

- **Material Requirement**: A ring requires less material than a sphere since it only partially encircles the star.
- **Structural Stability**: The gravitational forces acting on a ring are primarily perpendicular to the plane of the ring, potentially making it structurally stable. Earth's gravitational force varies depending on location, and rotating a sphere at a constant velocity to counteract this force uniformly across its surface would indeed present significant challenges. This is because the gravitational force experienced by an object depends on its distance from the centre of mass of the Earth, which varies with latitude and altitude. In the case of a rotating sphere, the centrifugal force generated by the rotation would also vary with distance from the axis of rotation. This means that regions closer to the axis of rotation would experience less centrifugal force compared to regions farther away, which could lead to imbalances in the forces acting on the sphere. Additionally, the rotational speed required to counteract Earth's gravitational force at one location may not be sufficient to do so at other locations due to the variability in gravitational strength. Achieving a uniform rotational velocity across the entire surface of the sphere to counteract Earth's gravitational force would therefore be impractical. In contrast, a ring structure could potentially be rotated at a constant velocity to generate centrifugal force that partially counteracts Earth's gravitational force. By adjusting the rotational velocity appropriately, it may be possible to achieve a more uniform distribution of forces along the circumference of the ring, making it more feasible to withstand Earth's gravitational force.
- **Accessibility** : A Ring may be more accessible for maintenance and repair due to its open structure, allowing for easier access to different sections. Rings offer flexibility in design and construction, allowing for incremental expansion or modification.
- **Interaction with space**: in ring we can explore the space and able to use sun's energy also.

2.2 Satellites around black hole

We can use 6 satellites around black hole each along the ends of the 3 axes. This provides comprehensive coverage and maximize the absorption of radiation. Ensuring that these satellites are positioned at a safe distance from the black hole is crucial to prevent them from being pulled into its event horizon by its immense gravitational pull. The satellites would need to be equipped with

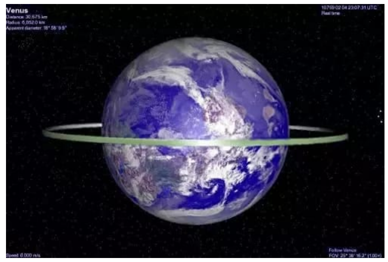


Figure 1: Rings around Earth

specialized instruments designed to absorb and capture the radiation emitted by the black hole. These instruments could include detectors for various wavelengths of electromagnetic radiation, such as X-rays, gamma rays, and radio waves, depending on the properties of the black hole. These satellites can be revolved around black hole with great velocities. For this high velocity they can use the energy that they are absorbing from black hole. Equipping the satellites around the black hole with functions to utilize a portion of the absorbed energy for their own functioning.

2.3 Laser Beam Wireless Power Transmission

Lasers are already used in space to transfer energy over large distances using microwaves. Space engineers are working on future concepts such as the transmitting of energy from solar arrays to power remote satellites. In the laser beam wireless power transmission technique, a laser beam sends concentrated light to a photovoltaic cell receiver through the vacuum of space and the atmosphere. The receiver converts the energy back into electricity through these steps:

- The DC power harvested in space is used to generate a single wavelength (monochromatic) light beam.
- A set of optics shapes the laser light according to the required beam size.
- A control system ensures that the laser is pointed at the intended receiver site on the ring.

The mode of operation of the photovoltaic receiver is similar to that of solar power harvesting in which the sunlight falling on solar cells produces electricity. However, this method uses high-intensity laser beams on specialized photovoltaic cells and allows for higher efficiency than what is currently possible with solar cells. Mirrors and telescopes can be used to aim the laser beam at any receiver directly below the satellite with an unobstructed-line-of-sight transmission path. Received energy is used to reach the critical conditions of temperature and pressure required for nuclear fusion reactions.

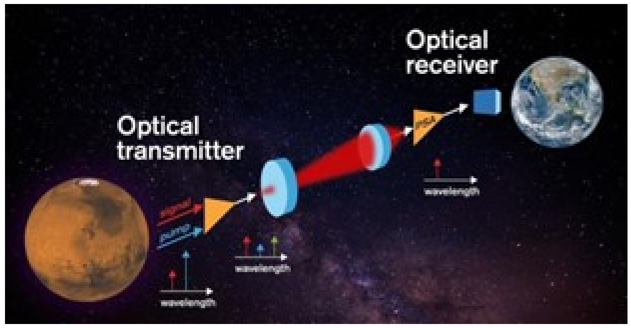
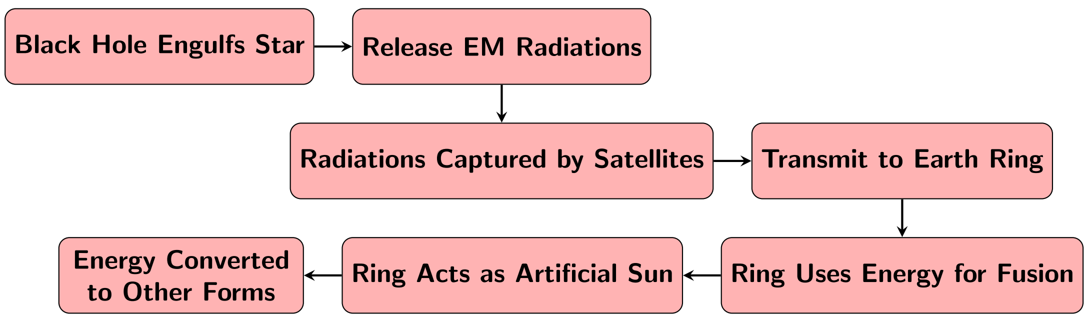


Figure 2: This is a systematic representation of laser beam power transmission

The systematic diagram of the process is as follows.



3 Solution 3

This represents the solution addressing the third problem statement.

3.1 Part 1

Assumptions:

- In this problem statement we are considering all the objects as point size, relative to each other
- $M >>> m$
- The black hole which is approaching the Earth is charged
- Due to opposite charges being induced on the planet, and mass being pulled towards the black hole, the density of that side has changed, the planet being electrically neutral

F= Total force on the rocket
M= Mass of Earth

m= Mass of Rocket
r= Radius of Earth
x= Arbitrarily distance between the Earth and Rocket
K= Coulomb's constant
G= Gravitational constant
v_e=Escape velocity

$F_g = \frac{GMm}{r^2}$ (Newton's law of Gravitation)

$F_q = \frac{Kq_1q_2}{r^2}$ (Coulomb's law)

$F = F_g + F_q$

$F = \frac{GMm}{x^2} + \frac{Kq_1q_2}{x^2}$

Taking $q_1 = q_1$ and $q_2 = -q_2$ due to opposite induced electrical charge

$F = \frac{GMm}{x^2} - \frac{Kq_1q_2}{x^2}$

Finding the total energy of the Rocket

$dW = Fdx$

$dW = \frac{GMm}{x^2} - \frac{Kq_1q_2}{x^2}$

$\int W = \int_r^\infty \frac{GMm}{x^2}dx - \int_r^\infty \frac{Kq_1q_2}{x^2}dx$

$W = \frac{GMm}{r} - \frac{Kq_1q_2}{r}$

This is the work done against the gravitational attraction to take the body from the planet's surface to infinity

To break free from the planet's surface, the kinetic energy of the object must match the energy expended in overcoming gravity's pull from the surface to an infinite distance.

K.E = W

$\frac{1}{2}mv_e^2 = \frac{GMm}{r} - \frac{Kq_1q_2}{r}$

$v_e^2 = \sqrt{\frac{2GM}{r} - \frac{2Kq_1q_2}{rm}}$

This is the new escape velocity for the rocket.

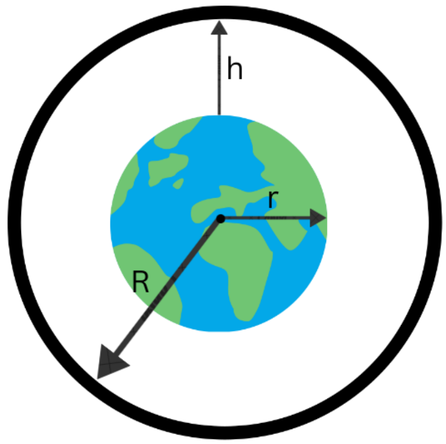


Figure 3: Systematic diagram showing R,r, and h

3.2 Part 2

v_o=Orbital velocity
R= Distance of the rocket from the Earth's center of mass
h= Height of rocket from Earth's surface

$R = r + h$

Centripetal force of moon = Force exerted by earth

$\frac{mv_o^2}{R} = \frac{GMm}{(R)^2} - \frac{Kq_1q_2}{(R)^2}$

$\frac{mv_o^2}{r+h} = \frac{GMm}{(r+h)^2} - \frac{Kq_1q_2}{(r+h)^2}$

$v_o^2 = \frac{GM}{(r+h)} - \frac{Kq_1q_2}{m(r+h)}$

$v_o = \sqrt{\frac{GM}{(r+h)} - \frac{Kq_1q_2}{m(r+h)}}$

Now, we will compare it with the actual orbital formula for elliptical orbit,

$v = \sqrt{\mu(\frac{2}{R} - \frac{1}{a})}$

μ= Standard Gravitation Parameter (GM, $M >>> m$)
R= Distance between orbiting body and centre of mass
a= Length of the semi-major axis

$v_o = \sqrt{\frac{GM}{r+h} - \frac{Kq_1q_2}{m(r+h)}}$

Taking out μ (GM) from the equation and multiplying $\frac{2}{2}$ with $\frac{1}{r}$, we get,

$$v_o = \sqrt{GM\left(\frac{2}{2(r+h)} - \frac{1}{\frac{GMm(r+h)}{Kq_1q_2}}\right)}$$

Comparing both the equation we saw,

a= $\frac{GMm(r+h)}{Kq_1q_2}$

R=2$(r+h)$

Hence, we can conclude that the orbit will no longer remain circular but will mould itself in elliptical path.

3.3 Part 3

- Strengthened structural durability to endure potential fluctuations in gravitational forces during launch and while in space
- Adjustments in navigation systems and thrust configurations
- Advance exercise machines for astronauts to withstand body changes
- Enhanced propulsion systems with the ability to modulate thrust levels for efficient navigation within altered gravitational conditions

3.4 Part 4

- Due to the instability of electric charges, electronic devices may experience malfunctions. To mitigate this risk, we should encase sensitive devices in conductive materials
- Execute accurate trajectory planning and control algorithms to consistently adapt the spacecraft's path and ensure it remains in a stable orbit around the L1 point
- Create a spacecraft equipped with resilient thermal management systems adept at controlling internal temperatures and dispersing surplus heat
- Protect vital spacecraft components and crew quarters by surrounding them with materials resistant to radiation, thus reducing the risk of radiation exposure

4 Solution 4

Given Date: 28-02-2081 and Time: 08:29:19

Password String: ”STX-NUL}-STX_BS$\tilde{/}$NUL_w:STX_v:SOH_v”

The scientists plan to restart the facility on December 31, 4354, at 16:57:55:627 (31-12-4354/16:57:55:627).

Decoding the password using ASCII values:

```
STX=2, NUL=0, BS=8, SOH=1

Decoding password,
We'll write ASCII Values of the string as it is:
2_119 0-125 2-127-8-126 0-119 2-118 1-118

Consider the first 3 sets as representing the date 28-02-2081 and
another 3 are representing time 08/29/19.
The digits that are in odd digit positions are the same as ASCII values,
but the digits in even digit positions are not the same as ASCII values.
However, if we observe them, we can notice a pattern that if we relate g
iven even position
with original values, the summation of all original values translated
and ASCII value is 127,
which is the last number of the ASCII value.

Using this logic:
We are encoding the password using Date 31-12-4354 and time 16:57:55:627.
We will write odd positions as it is as per ASCII values.
And we'll subtract even position digits with 127.
We'll continue this until the end.

Then we'll get our password as,
ETX_~ SOH}-EOT_|ENQ{SOH_y:ENQ_X:ENQ_z:ACK_d
```

ASCII Table

Dec = Decimal Value
Char = Character

'5' has the int value 53
if we write '5'-'0' it evaluates to 53-48, or the int 5
if we write char c = 'B'+32; then c stores 'b'

Dec	Char	Dec	Char	Dec	Char	Dec	Char
0	NUL (null)	32	SPACE	64	@	96	`
1	SOH (start of heading)	33	!	65	A	97	a
2	STX (start of text)	34	"	66	B	98	b
3	ETX (end of text)	35	#	67	C	99	c
4	EOT (end of transmission)	36	$	68	D	100	d
5	ENQ (enquiry)	37	%	69	E	101	e
6	ACK (acknowledge)	38	&	70	F	102	f
7	BEL (bell)	39	'	71	G	103	g
8	BS (backspace)	40	(	72	H	104	h
9	TAB (horizontal tab)	41	)	73	I	105	i
10	LF (NL line feed, new line)	42	*	74	J	106	j
11	VT (vertical tab)	43	+	75	K	107	k
12	FF (NP form feed, new page)	44	,	76	L	108	l
13	CR (carriage return)	45	-	77	M	109	m
14	SO (shift out)	46	.	78	N	110	n
15	SI (shift in)	47	/	79	O	111	o
16	DLE (data link escape)	48	0	80	P	112	p
17	DC1 (device control 1)	49	1	81	Q	113	q
18	DC2 (device control 2)	50	2	82	R	114	r
19	DC3 (device control 3)	51	3	83	S	115	s
20	DC4 (device control 4)	52	4	84	T	116	t
21	NAK (negative acknowledge)	53	5	85	U	117	u
22	SYN (synchronous idle)	54	6	86	V	118	v
23	ETB (end of trans. block)	55	7	87	W	119	w
24	CAN (cancel)	56	8	88	X	120	x
25	EM (end of medium)	57	9	89	Y	121	y
26	SUB (substitute)	58	:	90	Z	122	z
27	ESC (escape)	59	;	91	[	123	{
28	FS (file separator)	60	<	92	\	124	|
29	GS (group separator)	61	=	93	]	125	}
30	RS (record separator)	62	>	94	^	126	~
31	US (unit separator)	63	?	95	_	127	DEL

Figure 4: ASCII Values