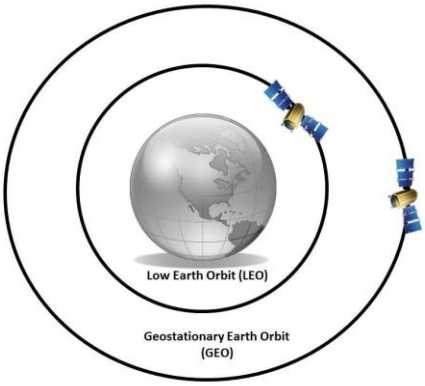
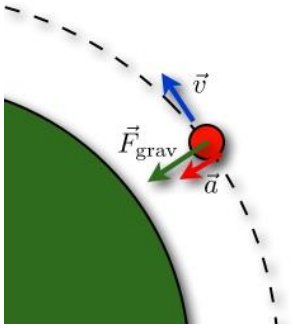
Gravitation Problem Set#1 2020

Force, Field strength, Circular Orbits

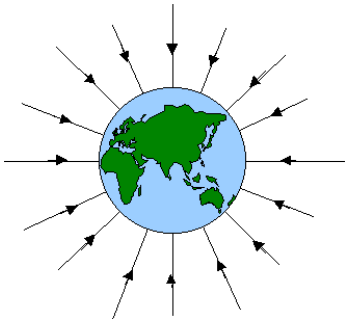
1. The approximate average altitude of the satellite Sputnik I was 560 km *above the surface* of the Earth. Find a) "g" at this height above the Earth b) Calculate the speed of the satellite in orbit c) Determine the period of the satellite.



2. A satellite is to be placed in a **circular orbit** at an altitude of 290 km above the surface of the Earth. a) What is the gravitational field strength at this location? b) What must the speed of the satellite be? c) What would be the period of the satellite?



3. At what height above the Earth's surface would the Earth's gravitational ***field strength*** be equal to 7.5 N/kg?



4. Find the gravitational attraction, which exists between a 60 kg boy and a 50 kg girl at a distance of 1 m.

5. A space ship of mass 1000 kg lands on Saturn, which has a radius of 6.0×10^7 m and a mass of 5.67×10^{26} kg. a) What is the **weight** of the spaceship on the surface of Saturn? b) What is **"g"** on the surface of Saturn?

6. An astronaut picks up a 4 kg rock on Jupiter. The radius of Jupiter is 7.18×10^7 m. The mass of Jupiter is 1.90×10^{27} kg. a) What force is required to pick up this rock? b) Find "g" at the surface of Jupiter.

7. What is the weight of a 60 kg person on Mars? The mass of Mars is 6.37×10^{23} kg and its radius is 3.43×10^6 m.

8. A 5 kg object weighs 30 N on the surface of a planet of mass 4.0×10^{28} kg. Find the radius of the planet.

9. An astronaut has landed on the planet Venus and finds that it takes a force of 48.6 N to lift his shovel. The mass of Venus is 4.83×10^{24} kg and its radius is 6.31×10^{6} m. What is the mass of the shovel?

10. A spaceship of mass 9.6×10^{3} kg lands on a spherical planet X which has a radius of 2.67×10^{7} m. A vertical lift off from the planet requires the overcoming of a gravitational field whose strength is 8.23 N/kg. a) What is the weight of the spaceship on the surface of planet X? b) What is the mass of planet X?

Answers

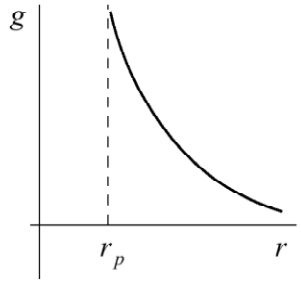
1. a) 8.29 m/s^2 b) 7595.9 m/s c) 5757 s = 96 min
2. a) 8.97 m/s^2 b) 7746 m/s c) 90.4 min
3. 915.8 km
4. 2.0×10^{-7} N
5. a) 10500 N b) 10.5 N/kg
6. a) 98.3 N b) –24.6 m/s^2
7. 217 N
8. 6.67×10^{8} m
9. 6.02 kg
10. a) 79000 N b) 8.8×10^{25} kg

Second Set

1.

Which graph best shows how the gravitational field strength, g, varies with the distance, r, from the centre of a planet? (r_p is the radius of the planet.)

A.



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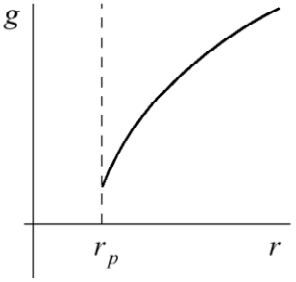
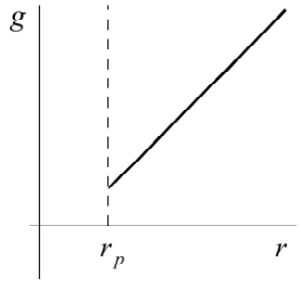
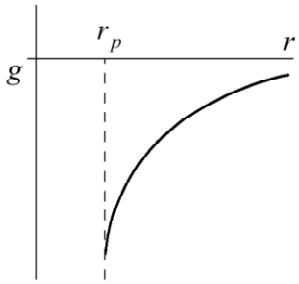


C.



D.



2.

A satellite is in a stable circular orbit around the earth. Another satellite in a stable circular orbit at a greater altitude must have

A. a smaller speed and a shorter period.
B. a smaller speed and a longer period.
C. a greater speed and a shorter period.
D. a greater speed and a longer period.

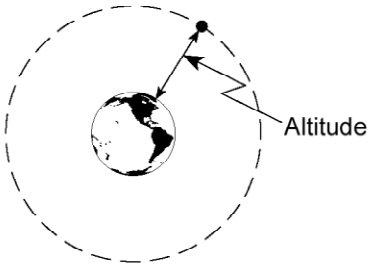
9.

a) Mars has a mass of 6.37×10^{23} kg and a radius of 3.43×10^{6} m. What is the gravitational field strength on its surface? **(4 marks)**

b) What thrust force must the rocket engine of a Martian lander exert if the 87.5 kg spacecraft is to accelerate upwards at 1.20 m/s^2 as it leaves the surface of Mars? **(3 marks)**

11.

A satellite experiences a gravitational force of 228 N at an altitude of 4.0×10^{7} m above Earth.



What is the mass of this satellite?

A. 23 kg
B. 650 kg
C. 910 kg
D. 1 200 kg

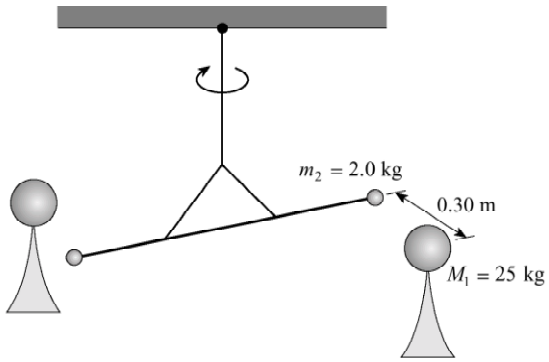
14.

A rock drops from a very high altitude towards the surface of the moon. Which of the following is correct about the changes that occur in the rock's mass and weight?

	MASS	WEIGHT
A.	decreases	decreases
B.	decreases	increases
C.	remains constant	decreases
D.	remains constant	increases

15.

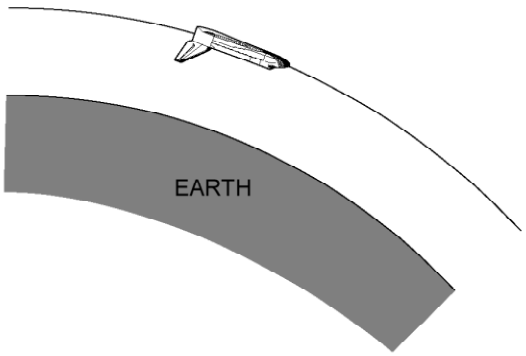
Cavendish's historic experiment is set up as shown to determine the force between two identical sets of masses. What would be the net force of attraction between **one** set of masses?



A. 1.1×10^{-8} N
B. 1.9×10^{-8} N
C. 2.2×10^{-8} N
D. 3.7×10^{-8} N

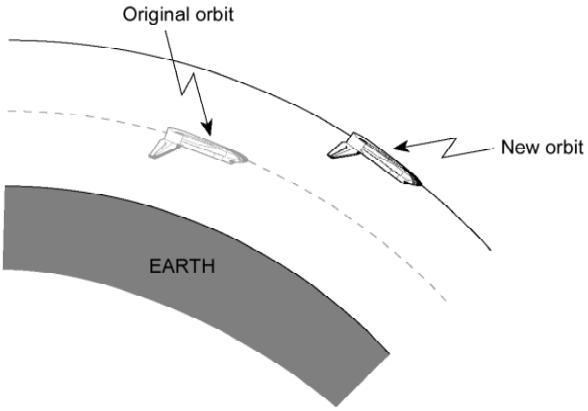
16.

A space shuttle is placed in a circular orbit at an altitude of 3.00×10^5 m **above** Earth's surface.



a) What is the shuttle's orbital speed? **(5 marks)**

b) The space shuttle is then moved to a higher orbit in order to capture a satellite.



The shuttle's speed in this new higher orbit will have to be

- ☐ greater than in the lower orbit.
- ☐ less than in the lower orbit.
- ☐ the same as in the lower orbit.

(Check one response.) **(1 mark)**

c) Using a formula and show your reasoning for part b) in the space below

17.

Sputnik I, Earth's first artificial satellite, had an orbital period of 5 760 s. What was the average orbital radius of *Sputnik's* orbit?

A. 6.38×10^6 m
B. 6.95×10^6 m
C. 8.24×10^6 m
D. 3.84×10^8 m

19.

A 5.0 kg rock dropped near the surface of Mars reaches a speed of 15 m/s in 4.0 s.

a) What is the acceleration due to gravity near the surface of Mars? **(2 marks)**

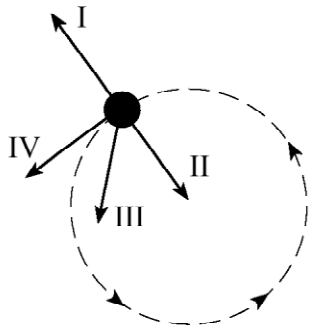
b) Mars has an average radius of 3.38 x 10^6 m. What is the mass of Mars? **(5 marks)**

21.

A 1 500 kg satellite travels around the earth in a stable orbit with a radius of 1.3×10^7 m.

a) What is the speed of the satellite in this orbit? **(5 marks)**

22.
A satellite moves in a circular path at a constant speed. Which vector in the diagram below best represents the satellite's acceleration?



A. I
B. II
C. III
D. IV

23.
What is the magnitude of Earth's centripetal acceleration as it orbits the Sun?

A. 1.9×10^{-10} m/s^2
B. 4.2×10^{-4} m/s^2
C. 5.9×10^{-3} m/s^2
D. 9.8 m/s^2

25.
A satellite wishes to orbit the earth at a height of 100 km (approximately 60 miles) above the surface of the earth. Determine the speed, acceleration and orbital period of the satellite. (**v = 7.85 x 10^3 m/s, a = 9.53 m/s^2 T = 5176 s = 1.44 hrs)**

Answers:

1. A
2. B
3. A
4. 30J
5. D
6. A
7. 7.86×10^{24}kg 2.72×10^{10}J
   -2.72×10^{10}J
8. D
9. 3.61 N/kg 421N
10. D
11. D
12. A
13. 1.2×10^{10}J
14. D
15. D
16. 7.73×10^{3} m/s (less than in lower orbit)
17. B
18. C
19. 3.8 m/s^2 6.5×10^{23} kg
20. D
21. 5.5×10^{3} m/s (less than)
22. B
23. C
24. D
25. Answers given
26. 1.2×10^{6} m
27. 6.2 m/s
28. 3.41×10^{9} J