Advanced Higher Physics

Astrophysics

Problems:

Solutions

## Tutorial 1.0

**Gravitation**

1. F = 

2. F =  = 2.7 x 10-4 N

3. F =  = 3.5 x 1022 N

4. (a) F = m1g =  giving g =  where M is the mass of the Earth

 (b) (i) 9.8 =  giving M = 6.0 x 1024 kg

 (ii) g =  = 9.8 N kg-1 (No noticeable difference!)

 (iii) g =  = 9.2 N kg-1

5. (a) The work done to move 1 kg from infinity to that point.

 (b) Vp = - 

 (c) (i) Vp = -  = - 6.2 x 107 J kg-1

 (ii) Vp = -  = - 5.6 x 107 J kg-1

 (The negative sign indicates that the potential at infinity is higher than the potential on or close to the Earth.)

6. The work done *by the force of gravity* on a particle which moves through a round trip back to its starting point is zero. Energy is conserved.

7. Energy required = Ek + Ep and Ek = ½ mv2 but 

 =  +  = -  = -

 = - 5.9 x 1012 J (The negative sign indicates a decrease in energy.)

8. Gravitational field strength, escape velocity

9. (a) -10 – (-15) = 5 J kg-1

 (b) 5 x 8 = 40 J

 (c) 40 J

10 (a) The minimum velocity a mass must have that would allow it to escape from the gravitational field of the planet or star.

 (b) Gravitational Ep at surface = -  Ep(Infinity) = 0

 Kinetic energy at surface = ½ mv2 Ek(Infinity) = 0

 Total energy at surface = total energy at infinity

 -  + ½ mv2 = 0 thus v2 =  and vescape = 

 (c) (i) ve(Earth) = 1.1 x 104 m s-1 ve(Moon) = 2.4 x 103 m s-1

 (ii) Escape velocity on the Moon is very small so there will be no atmosphere.

11. For a geostationary satellite T = 24 x 60 x 06 s and T = 2 

 for the Earth this gives r = 4.2 x 107 m, where r is from the centre of the Earth

 Ep = -  = - 1.9 x 1011 J Ek =  = 0.95 x 1011 J

12. (a) See Mechanics – Student Material page 25

 (b) (i) 24 hours (24 x 60 x 60 s)

 (ii) radius of orbit = 4.2 x 107 m, (using the equation for T as in Q 11.)
 height above equator = 4.2 x 107 – 6.0 x 106 = 3.6 x 107 m

 (iii) v = r = r = 3.05 x 103 m s-1

 (iv) central acceleration =  = 0.22 m s-2

13. (a) density =  = 1.1 x 109 kg m-3

 (b) Vp = -  = - 1.99 x 1013 J kg-1

 (c) g =  = 2.5 x 106 N kg-1

 (d) Assume a change of height of 1 m and a mass of 60 kg

 Ep = mgh = 60 x 2.5 x 106 x 1 = 1.5 x 108 J

 (e) s = ut + ½ at2 giving 100 = 0 + ½ x 2.5 x 106 x t2

 t = 8.9 x 10-3 s (Notice that this does not depend on the mass)

14. (a) There is a gravitational force of attraction on the photons. The photon path would be deflected.

 (b)

Apparent position of star

To true position of star

 The light from the star is deflected by the Sun. The observer might consider that the star position is in a straight line from his line of sight.

 (c) If a dense star has an escape velocity greater than the speed of light, then no light could escape and the star would appear ‘black’.

## Tutorial 1.1

**Gravitation**

 







(a)

(b)

## Tutorial 2.0

**Space and time**

Numerical answers:

18. 6.67 × 104 m

19. 1.8 × 104 m

20. 3000 m

21. 8.9 × 10–3 m (8.9 mm)

22. 4.7 × 103 m

## Tutorial 3.0

**Stellar physics**

Numerical answers:

1. (a) 4410 K

(b) 2.1 × 107 W m–2

2. (a) 6.42 × 107 W m–2

 (b) 3.95 × 1026 W

 (c) 1.4 × 103 W m2

3. (a) 12500 K

 (b) 1.38 × 109 J (m–2 s–1)

 (c) 3.9 × 1028 W

 (d) 1.5 × 109 m

4. 5.8 × 10–9 W m–2

5. 1.8 × 1028 W m–2

6. (a) 1.45 × 1018 m

 (b) 153 ly

7. 5.5 × 1016 m (5.8 ly)

8. 5.3 × 10–8 W m–2

9. Show *L* = 4π*r*2σ*T*4

10. Show that apparent brightness = σ*r*2*T*4/*d*2

12. 80

13. (a) 324

(b) Star A; 18 times more distant than star B.