[**VISUAL PHYSICS ONLINE**](http://www.physics.usyd.edu.au/teach_res/hsp/sp/spHome.htm)

**5: Advanced Mechanics**

**Projectile Motion**

**P5160**

A golfer strikes a ball sitting on the ground on a level golf course. The ball hits the ground 180 m north from where it was struck, 5.6 s later. Assuming air resistance is negligible find: (a) the maximum height the ball reached, (b) the initial velocity (direction and magnitude) of the ball as it left the golf club.

**A5160**

(a) *ymax* = 38.4 m

(b) *u* = 42.3 m.s-1 θo = 40o

w.r.t. ground

**P5234** A ball thrown in the air traces a path as shown. What does the diagram tell you? (HSC 2005)

**A5234**



*ax* = 0 ⇒ *vx* = constant

*a*y = constant

*vy* always changing – decreases going up, zero at max height, increase as it falls

 always changing

**P5293**

How could you design a pendulum to have a period of 1 s, 1 min, 1 hour?

**A5293**

*L*1(1 s) = 0.25 m *L*2(1 min) = 8.9×102 m *L*3(1 h) = 3.2×106 m

**P5487**

Describe an experiment where a ball is dropped from different heights in a vacuum to determine the value of the acceleration due to gravity at the surface of the Earth. You need to describe the equipment used and how it was set up, the results you collected, how you analyzed them and the conclusion(s) you drew from them. You should use scientific diagrams where possible to aid your description.

**A5487**

A ball dropped from different heights using an electromagnet and a touch sensitive pad to accurately record the time taken for each fall. Collect data for the height dropped *h* and the time taken t to fall. Plot a graph of the height vs time2 (*h* vs *t*2)and draw a line of best fit. The gradient of the line will be equal to *g*/2 and *g* can be calculated in this way.

**P5555**

A cannon fires a shot with a horizontal velocity of 200 m.s-1 from the top of a cliff 30.0 m above the level of the sea. Calculate (a) the time taken for the shot to travel from the cannon to the sea, (b) the range of the cannon ball hitting the water. (HSC School Exam 2008).

**A5555**

(a) *t* = 2.47 s (b) *x* = 496 m

**P5682**

Two projectiles are fired at the same initial speed on level ground. Prove that that if one projectile was launched at an angle of θ w.r.t. the ground and the other at an angle φ such that (θ + φ) = 90o that they have the same range. For the case when θ = 60o and φ = 30o, which projectile takes the longest time to hit the ground? Sketch for the two projectiles (a) the trajectory and (b) the vertical displacement against time.

**P5682**

Two projectiles are fired at the same initial speed on level ground. Prove that that if one projectile was launched at an angle of θ w.r.t. the ground and the other at an angle φ such that (θ + φ) = 90o that they have the same range. For the case when θ = 60o and φ = 30o, which projectile takes the longest time to hit the ground? Sketch for the two projectiles (a) the trajectory and (b) the vertical displacement against time.

**P5921**

A cannon ball was observed by Isaac Newton to be fired at a velocity of 300 m.s-1 and at an angle of 30o from the horizontal. Determine: (a) the horizontal and vertical components of its initial velocity, (b) time taken to reach its maximum height, (c) the maximum height of the cannon ball, (d) the range of the cannon ball. (HSC School Exam 2008).

**A5921**

(a) *ux* = 260 m.s-1 (259.81 m.s-1) *uy* = 150 m.s-1

(b) *t* = 15.3 s

(c) *ymax* = 1.14×103 m

(d) *xmax* = 7.95×103 m

**Gravitation -------------------------------------------------------------------------**

**P5378**

A remote sensing satellite has been placed in a circular orbit with a period of 1.5 h. Determine the distance above the Earth’s surface and its speed.

Earth’s mass *ME* = 5.97×1024 kg Earth’s radius *RE* = 6.38×106 m

universal gravitation constant *G* = 6.673×10-11 N.m2.kg-2

**A5378**

*h* = 2.8×105 m *v* = m.s-1

**P5440 (23 24 25)**

(a) Determine the gravitational potential energy of a 1000 kg communications satellite orbiting the Earth at an altitude of 40 000 km.

(b) Calculate the change in gravitational potential energy when the 3177 kg space shuttle is launched from the surface of the Earth into a 400 km altitude low Earth orbit.

(c) How much work must be done to increase the altitude of a 1000 kg satellite by 5000 m (assuming its mass is unchanged)?

**A5440**

(a) -1561 J

(b) 2.0 x 1011 J

(c) 4.9 x 107 J

**P5489**

What is the value of *g* on the top of Mount Everest, *h* = 8848 m

**A5489**

*g* = 9.77 m.s-2

**P5542**

If an astronaut with all his gear on weights 240 N on the Moon, what is their mass on the surface of the Earth? Gravitational field strength on the Moon is (1/6)th of that on Earth.

**A5542**

150 kg

**P5593**

A spy satellite of mass 1000 kg is orbiting the Earth (*RE* = 6380 km) at an altitude of 300 km. (a) What is its period? (b) What is its orbital speed? High resolution photographs on film are sent back to Earth in a special container which can withstand a maximum acceleration of 8*g*. The container and contents have a mass of 50 kg. (c) Calculate the kinetic energy of the container as it traveling with the satellite. (d) The gravitational potential energy of the container relative to the surface of the Earth is the difference between the gravitational potential energy of the container in the satellite and the gravitational potential energy at the Earth’s surface. Calculate this value. (e) Determine the shortest time the container’s velocity can be brought to zero. (f) If the total orbital energy = kinetic energy + gravitational potential energy relative to the surface, determine the rate energy must be lost to remove the orbital energy of the container by the time it reaches the Earth’s surface.

**A5593**

(a) *T* = 90 min (b) *v*orb = 2.8×104 km.h-1 = 7.78×m.s-1

(c) *EK* = 1.51×109 J (d) *Ep* = 1.41×108 J

(e) *t* = 99.2 s (f) *E* = 1.65×109 J rate energy loss = 1.66×107 J.s-1

**P5674**

The initial velocity required by a space probe to just escape the gravitational pull of a planet is called *escape velocity*. What quantities affect the magnitude of the escape velocity?

**A5674**

escape velocity from surface of planet 

**P5738**

Given the radius of the Earth is 6400 km, a rocket places a satellite into a stable orbit of altitude 4020 km. Calculate the period of the satellite,

**A5738**

*T* = 10.6×104 s

**P5777**

A space probe P is in a stable orbit around small, distant planet. Sketch the orbit of the space probe. The probe fires a forward-facing rocket that reduces its orbital speed by half. Sketch the subsequent motion of the planet. (HSC 2005).

**P5876**

Calculate the escape velocity from the Earth’s surface (m.s-1 and km.h-1).

Earth’s mass *ME* = 5.97×1024 kg Earth’s radius *RE* = 6.38×106 m

universal gravitation constant *G* = 6.673×10-11 N.m2.kg-2

**A5876**

*vesc* = 1.12×104 m.s-1 = 4.0×104 km.h-1

**P5899**

Compare the orbital radius of a geostationary satellite above Mars with that above the Earth.

mass of Mars = 6.42×1023 kg

period of rotation of Mars = 24 h 47 min

radius of Mars = 0.53 × radius of Earth

*ME* = 5.97×1024 kg Earth’s radius *RE* = 6.38×106 m

**Kepler’s laws -------------------------------------------------**

**P5661**

From nearest to furthest, the four satellite moons of Jupiter first observed by Galileo in the year 1610 are called Io, Europa, Ganymede and Callisto. For the first three moons, the orbital period **T** of each is exactly twice the period of the one orbiting immediately inside it. That is

***T***Europa 2 ***T***Io  ***T***Ganymede 2 ***T***Europa

The mass of Jupiter is 1.90×1027 kg, and the orbital radius of Io is 421 600 km.

(a) Use Kepler’s Law of Periods to calculate Ganymede’s orbital radius.

(b) Calculate Ganymede’s orbital speed. (HSC 2005)

**A5661**

*T*E 2 *T*I  *T*G = 2 *T*E = 4 *T*I

mass of Jupiter *M* = 1.90×1027 kg

orbital radius of Io *r* = 421 600 km = 4.216×108 m

*G* = 6.67×10-11 N.m2.kg-2



(a)

Io 

Ganymede 



alternatively



(b) 

alternatively

centripetal force = gravitational force 