An approach to teaching and learning

Design and Communication Graphics

Solids in Contact

Syllabus Learning Outcomes:

- Construct views of up to three solids having curved surfaces and/or plane surfaces in mutual contact

- Construct views of solids given the point of contact

- Determine point of contact for surfaces in mutual contact

- Model various problems involving solids in contact, planes of reference and auxiliary planes

- Determination of oblique and tangent planes

Solids in Contact

The Sphere

A **sphere** is a **revolved feature**. It is created by revolving a **semicircle** around its **diameter**.
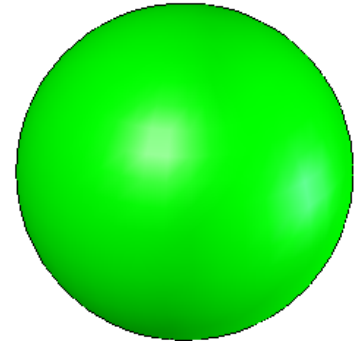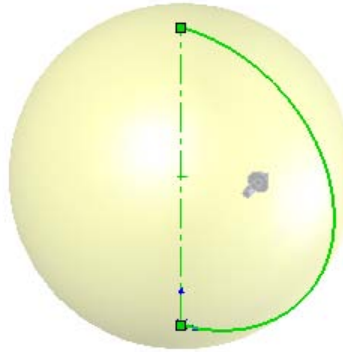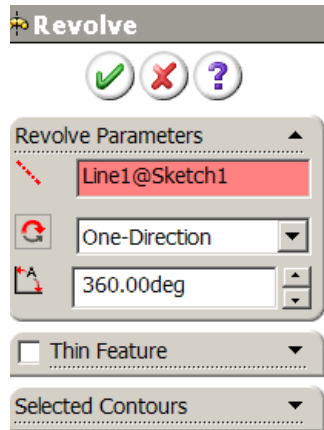
SW Exercise: Create a **sphere** of radius 30mm by revolving a semicircle around its diameter. Edit the colour of the part.

Sections of a Sphere

If a **cutting plane** passes through a solid, the actual part of the solid cut by the plane is called a **section**. When a cutting plane passes through a **sphere**, the resulting **section** is always a **circle**.
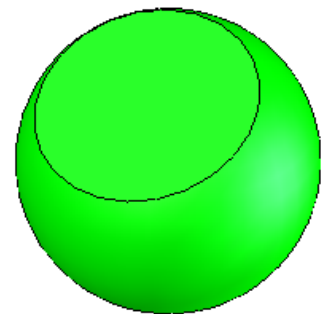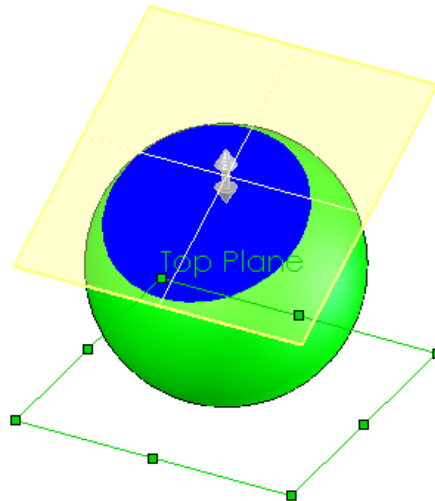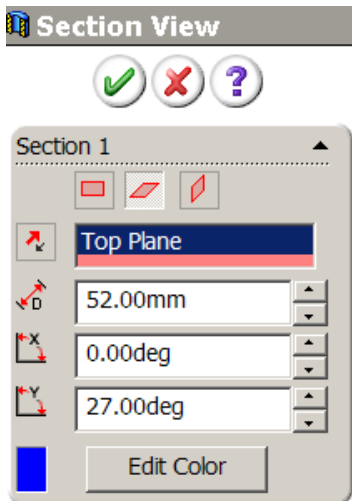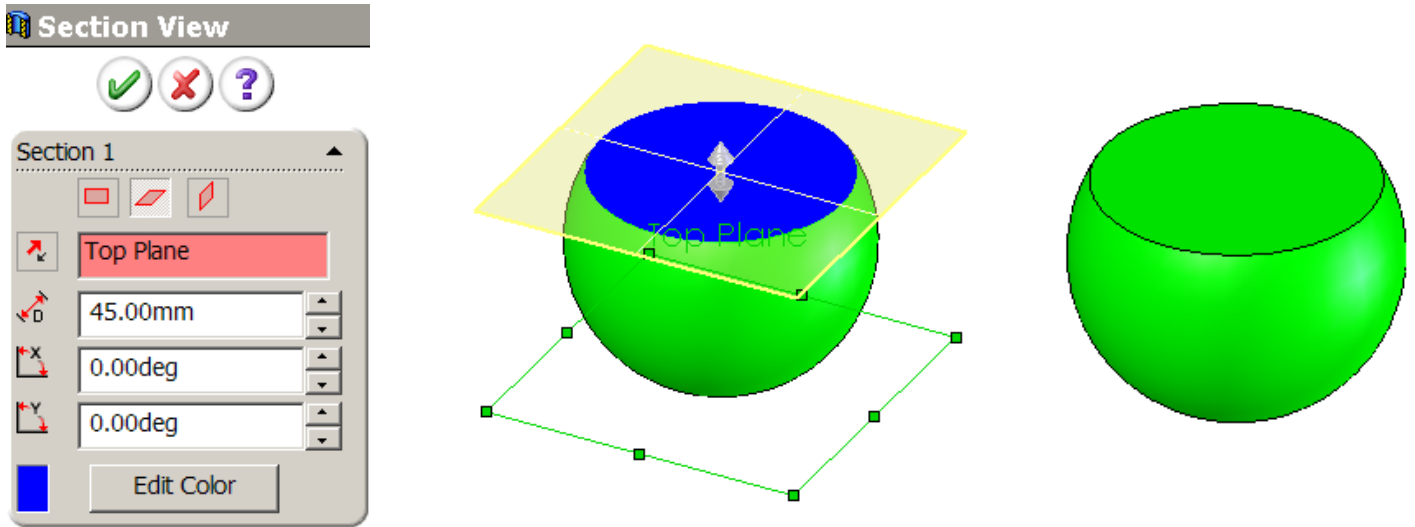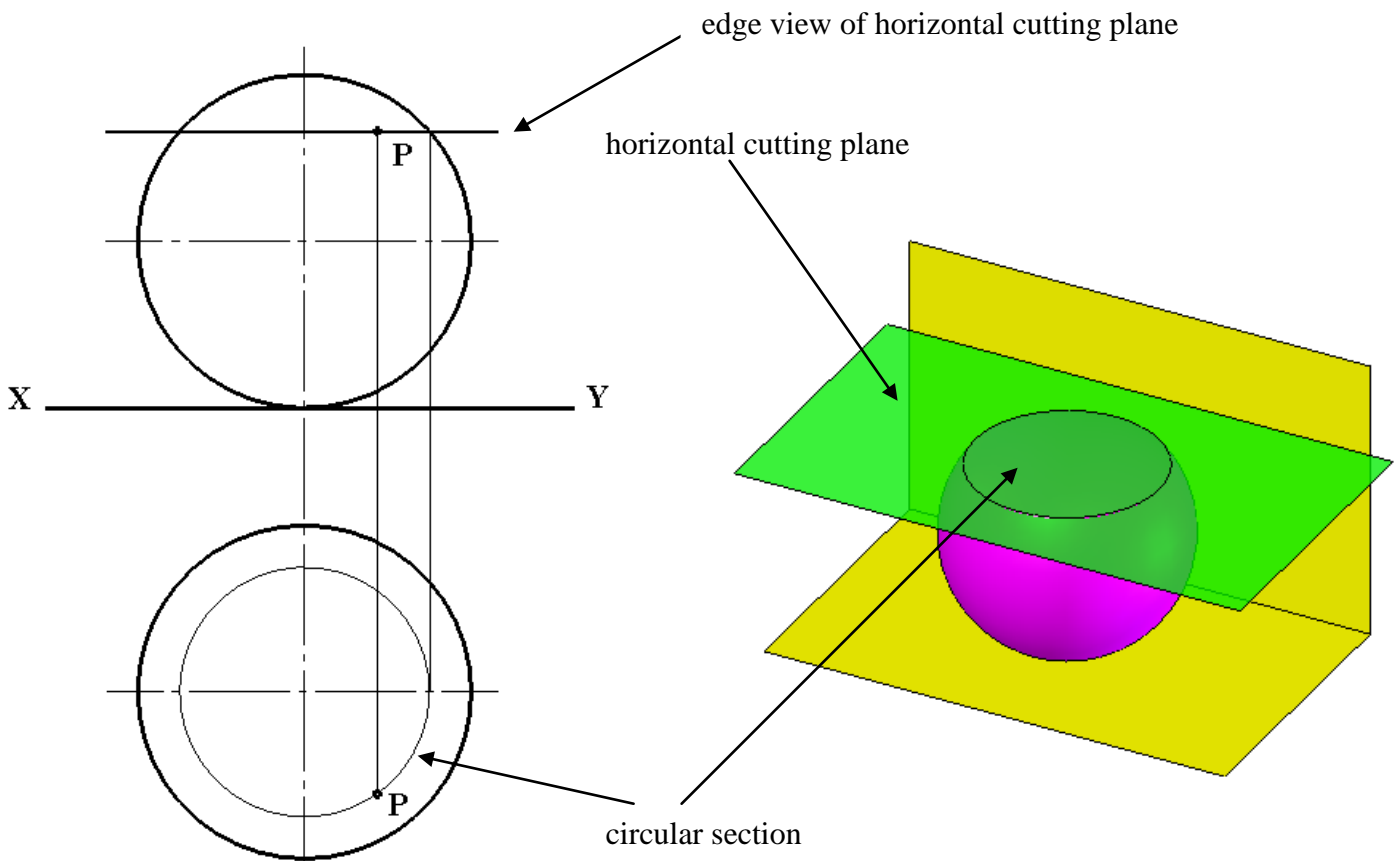
All **sections** of a sphere are **circles**.

SW Exercise: Create a **sphere** of diameter 80mm and display a **Section View** of the part.

Horizontal Sections of a Sphere

If a **horizontal** cutting plane passes through a sphere, the resulting section will appear **circular** in **plan**. This information allows us to determine the plan of a point P on the surface of a sphere when given the elevation of that point.

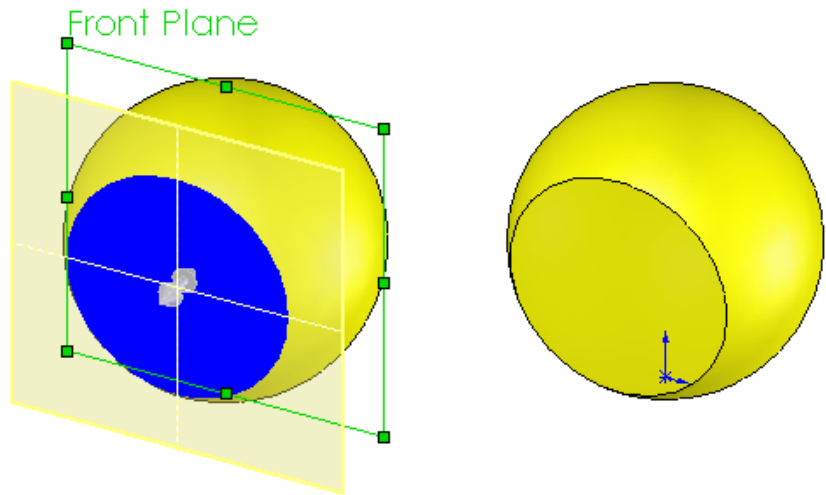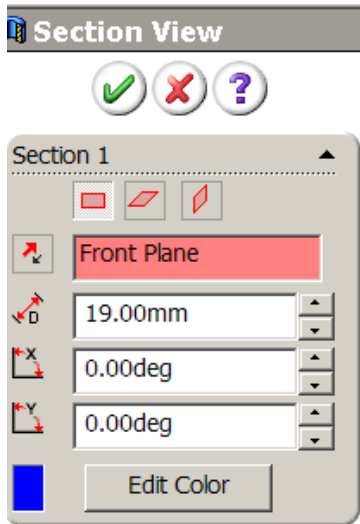**Example 1**   The figure below shows the projections of a sphere. Also shown is the elevation of a point P on the **front** of the sphere. Determine the plan of P.

edge view of horizontal cutting plane

horizontal cutting plane

P

X ———————————— Y

circular section

P

A **sphere** appears as a **circle** in all orthographic views.

All horizontal sections of a sphere appear as circles in plan.

Vertical Sections of a Sphere

If a **vertical** cutting plane passes through a sphere, the resulting section will appear **circular** in **elevation**. This information enables us to determine the elevation of a point P on the surface of a sphere when given the plan of that point.

Example 2   The figure below shows the projections of a sphere. Also shown is the plan of a point P on the **upper side** of the sphere. Determine the elevation of P.
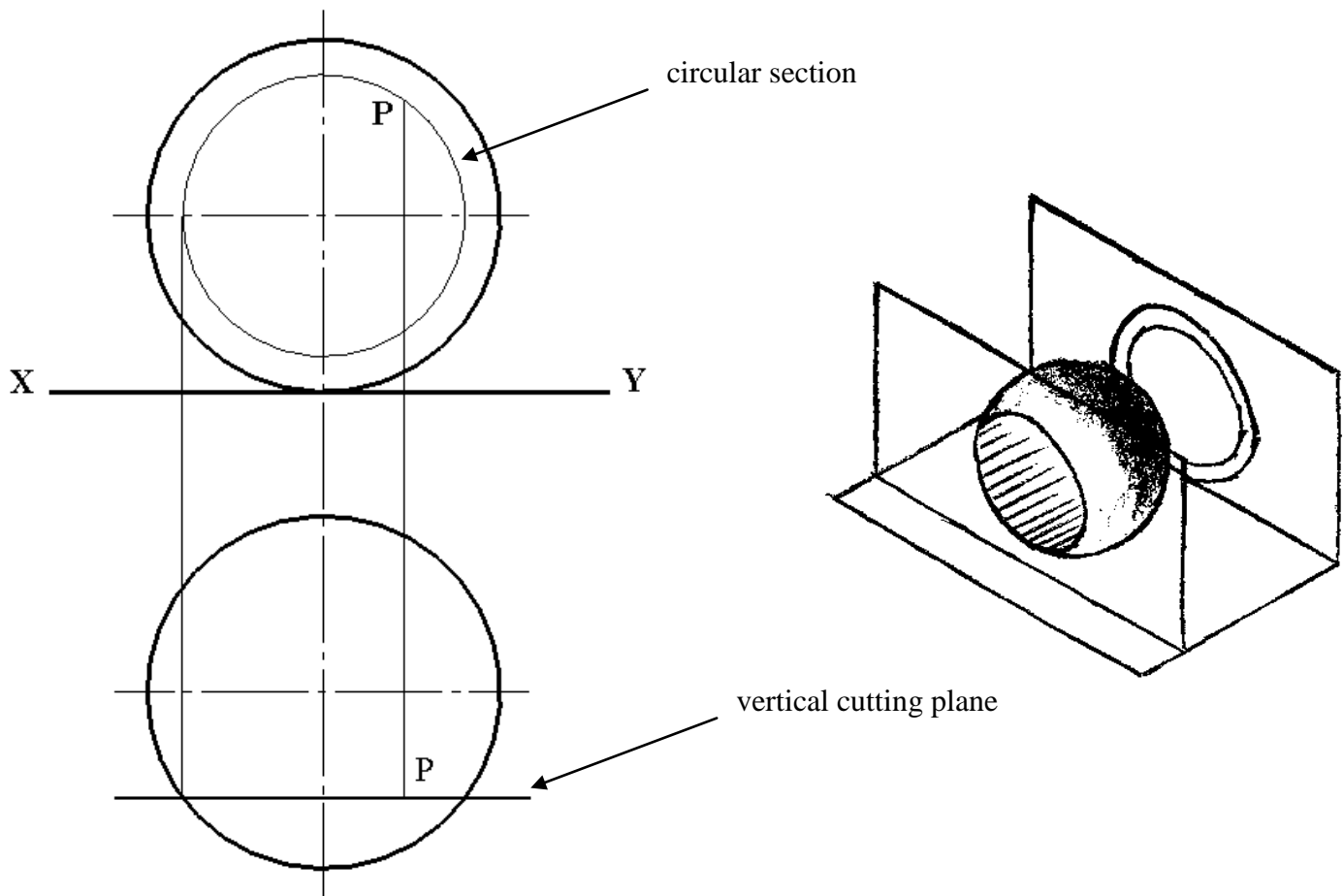

circular section

vertical cutting plane

Spheres in Contact

The photograph over shows the balls set up in a triangular frame for a game of pool. Each ball is in contact with at least two others. Two spheres are said to be in contact if their intersection consists of a single point.

> - If two spheres touch one another, the point of contact and the centres of the spheres are in the same straight line.
> - The distance between their centres is equal to the sum of their radii.
> - The point of contact between two spheres divides the line segment joining the two centres in the ratio of their radii.
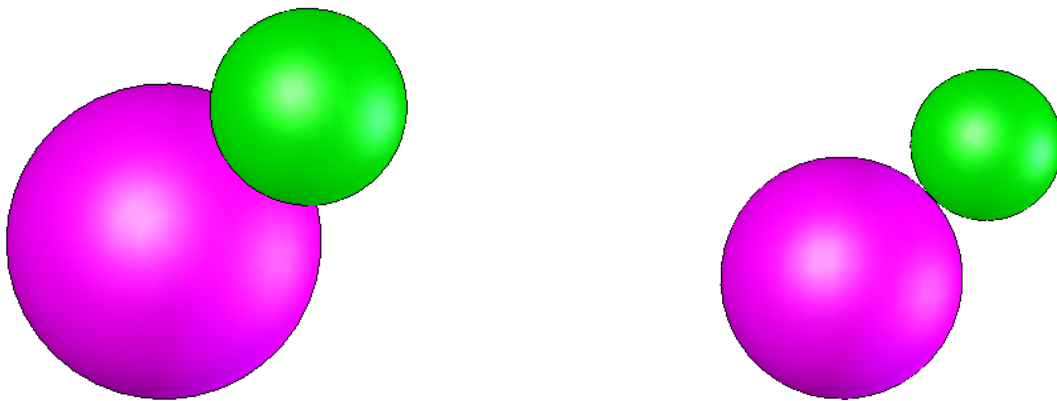
Students should be able to:

- Draw the projections of a sphere of given radius to touch a given sphere at a given point.

- Draw the projections of a sphere of given radius to touch a given sphere and rest on the H.P.

- Draw the projections of a sphere to touch a given sphere at a given point and to rest on the H.P.

- Draw the projections of three given spheres which touch one another and rest on the H.P.

The Cone

A **cone** is created by revolving a **right-angled triangle** around one of the arms of the **right angle**.
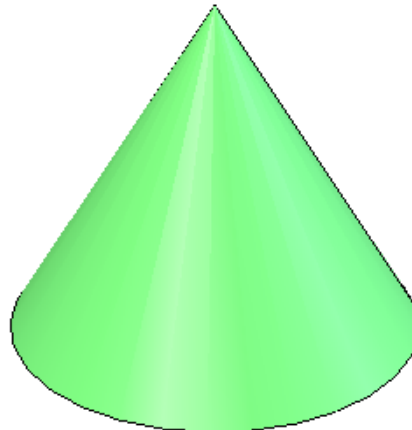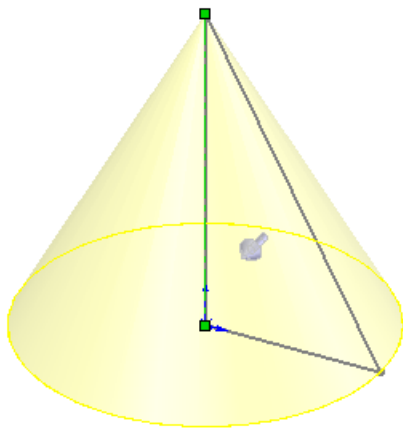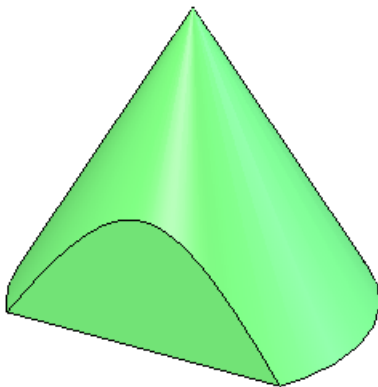
SW Exercise: Create a **cone** having a base of radius 30mm and a height of 55mm by revolving a right-angled triangle around one of its sides. Edit the colour of the part.

Sections of a Cone

When a cutting plane passes through a **cone**, the resulting **section** is called a **conic section**. SolidWorks can be used to display the various section views of a cone.
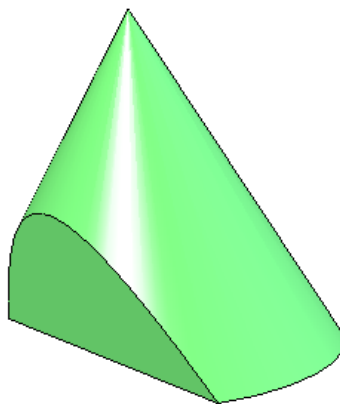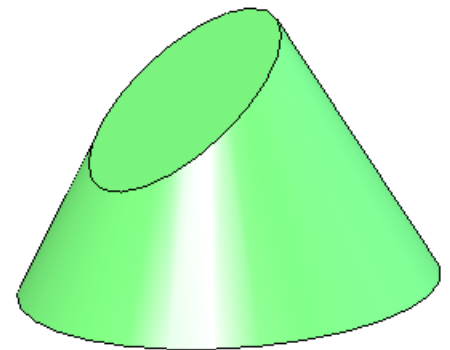
Parabola   Ellipse   Hyperbola

If a cone is cut by a cutting plane and one portion removed, the result is a **truncated** cone. If the cutting plane is parallel to the base of the cone the portion containing the base is called a **frustum**.

Frustum of a cone

Horizontal Sections of a Cone

When a **horizontal** cutting plane passes through a cone resting with its base on the H.P., the resulting section will be **circular** and will appear as a circle in plan. This information enables us to determine the plan/elevation of a point P on the surface of a sphere when given the elevation/plan of that point.

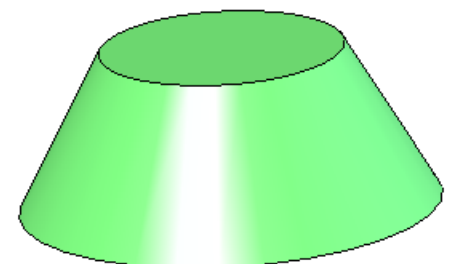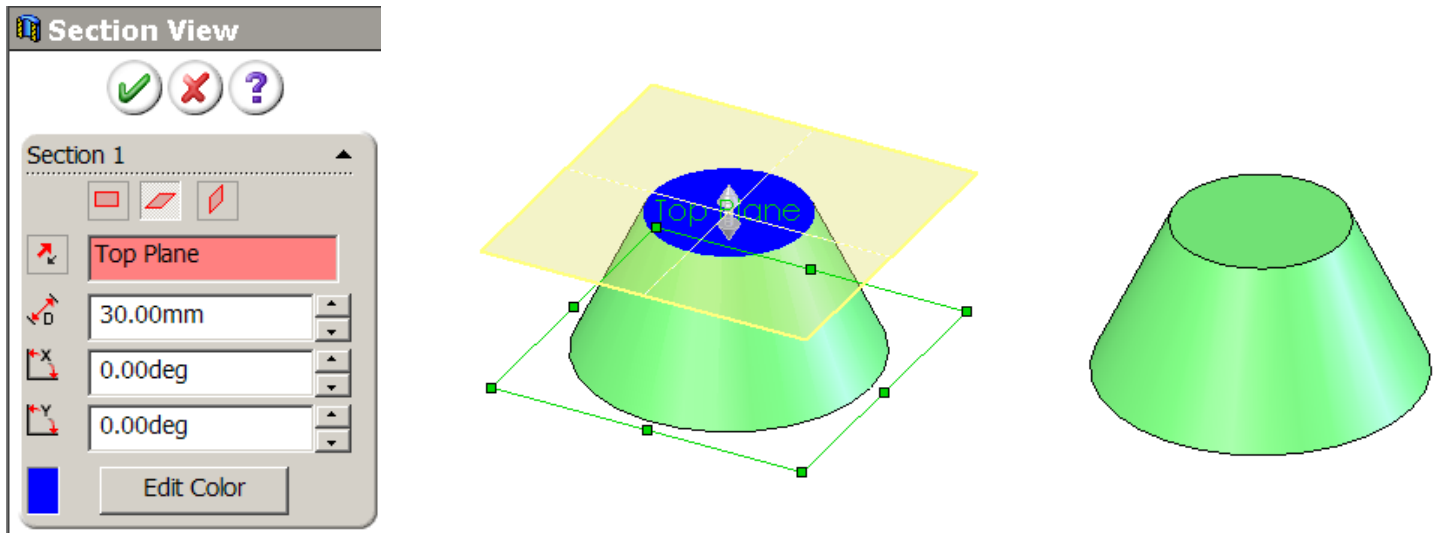**Example 3**   The figure below shows the projections of a cone. Also shown is the elevation of a point P on the **front** of the cone. Determine the plan of P.

edge view of horizontal cutting plane

edge view of HP

horizontal trace of cone

trace on cone in section plane is parallel to trace of cone on H.P.

circular section
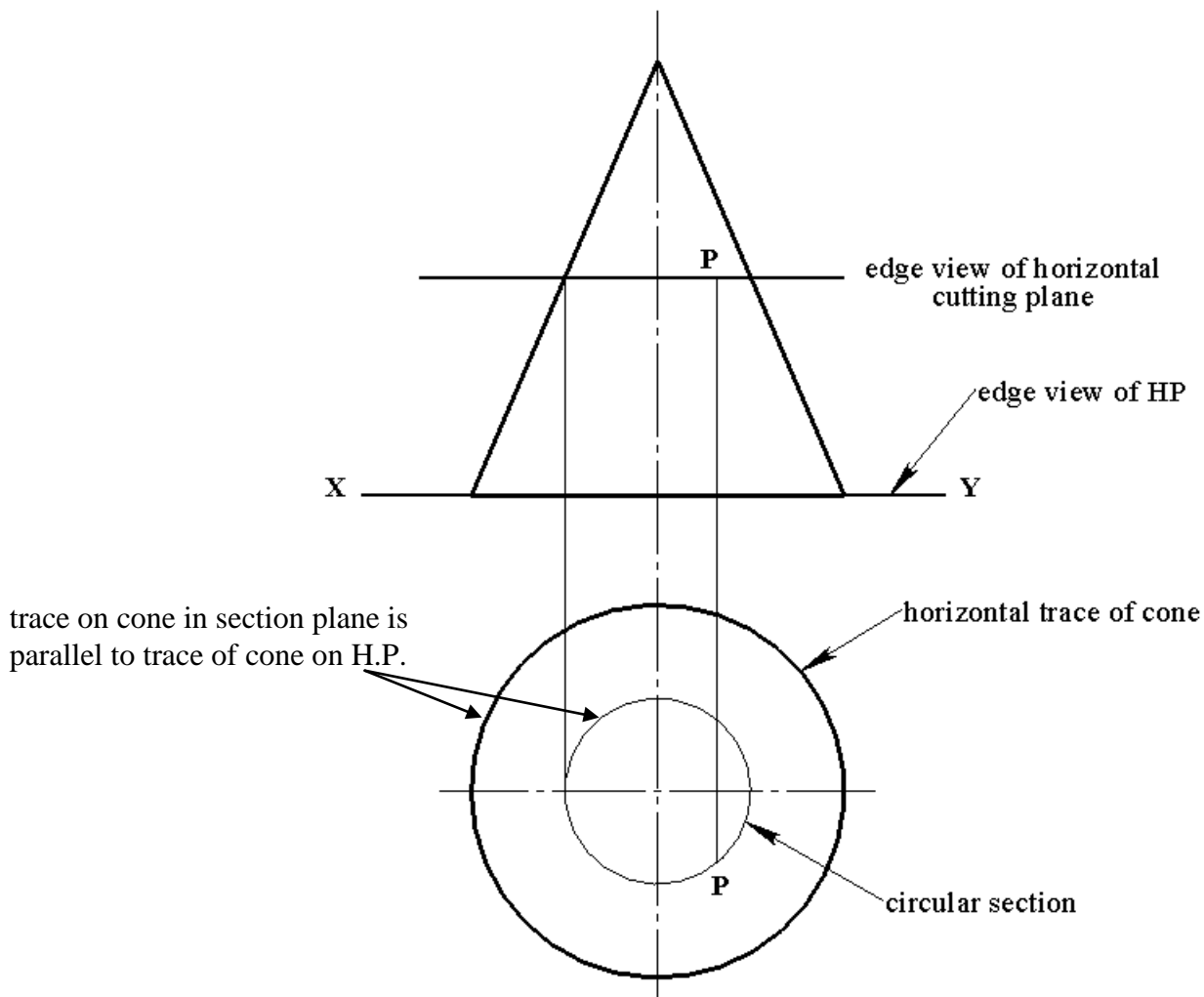
The Cone and Sphere in Contact

If a **sphere** is in contact with a **cone**, the line joining the point of contact and the centre of the sphere is perpendicular to the element of the cone that contains the point of contact.

Example   The elevation and plan of a **cone** and **sphere** (R35mm) in mutual contact are shown below. The
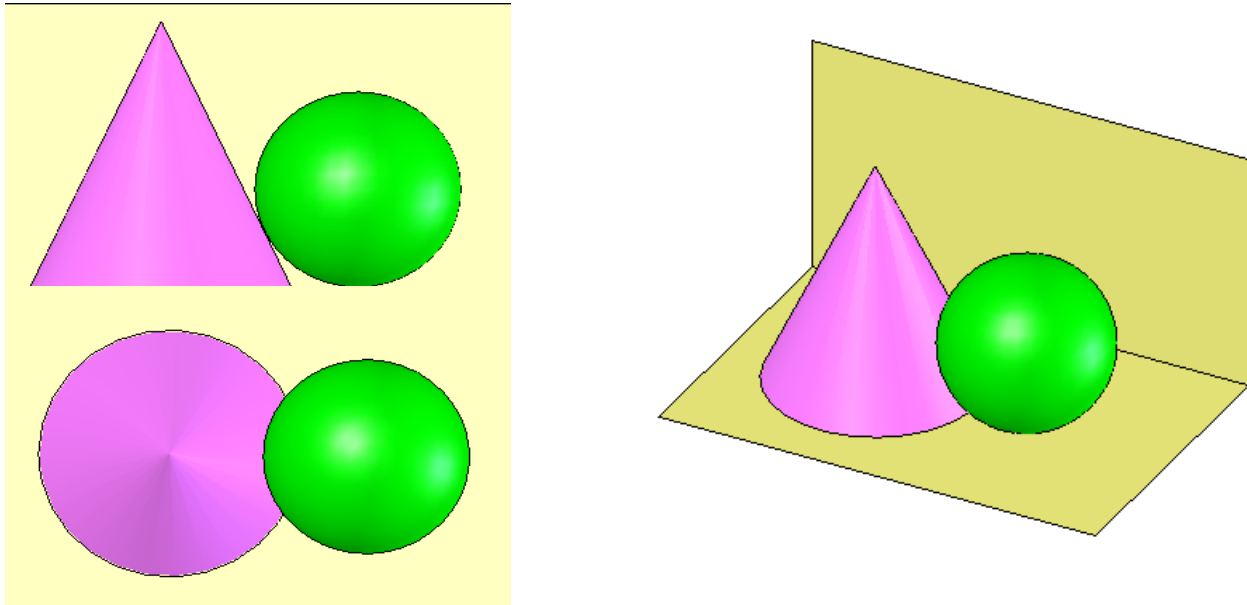projections   of the point of contact are also determined.
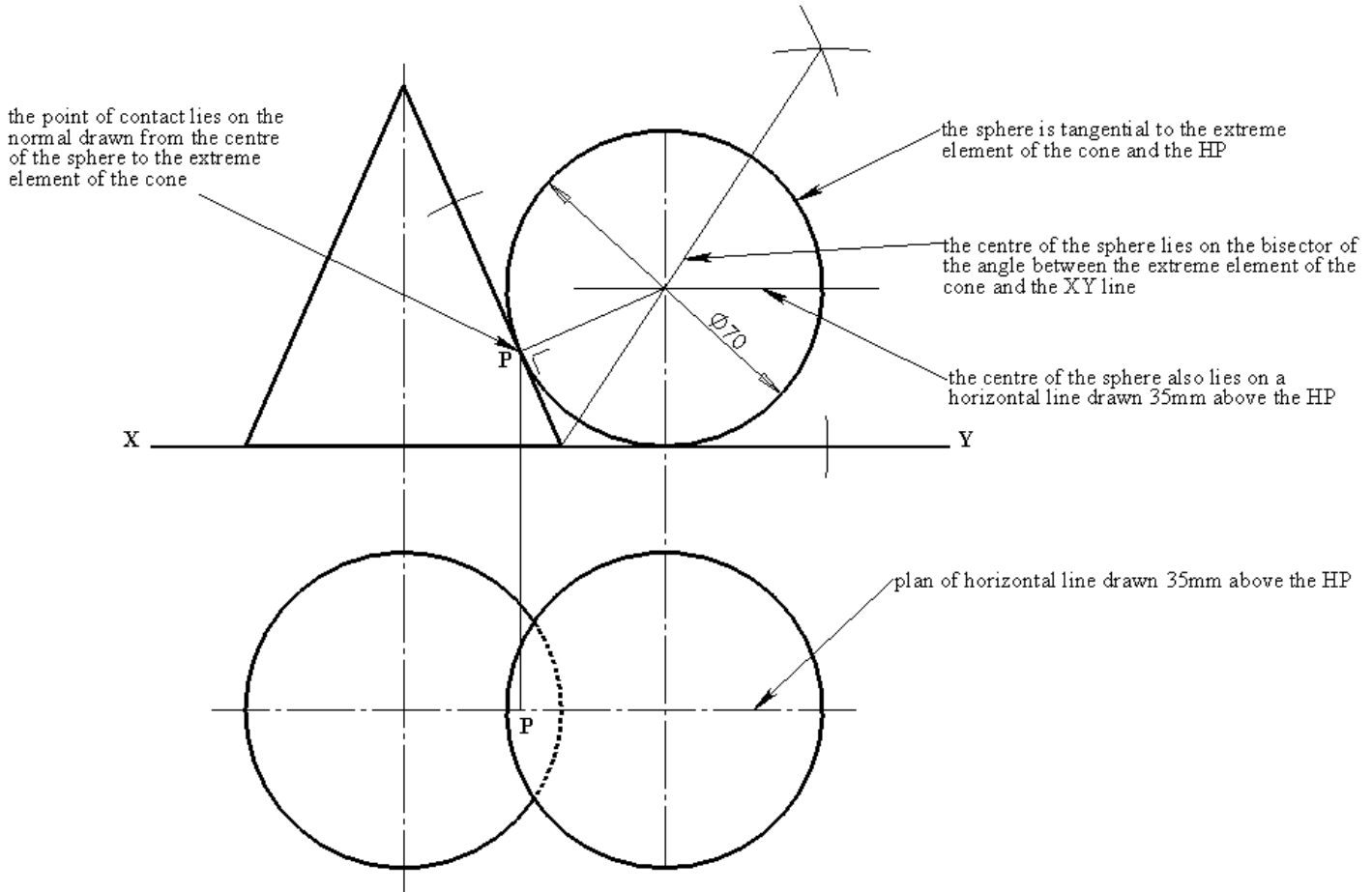
the point of contact lies on the normal drawn from the centre of the sphere to the extreme element of the cone

the sphere is tangential to the extreme element of the cone and the HP

the centre of the sphere lies on the bisector of the angle between the extreme element of the cone and the XY line

Ø70

the centre of the sphere also lies on a horizontal line drawn 35mm above the HP

X

Y

P

plan of horizontal line drawn 35mm above the HP

P

Students should be able to:

- Draw the projections of a sphere of given radius to touch a given cone at a given point

- Draw the projections of a sphere of given radius to touch a given cone and rest on the H.P.

- Draw the projections of a sphere which shall touch a given cone at a given point and rest on the H.P.

- Draw the projections of a sphere of given radius which rests on the H.P. and is in mutual contact with a given cone and sphere

The Cylinder

A **cylinder** can be considered to be a stack of circles. It may be created by **extruding** a **circle** from the sketch plane through a distance equal to its height or by **revolving** a **rectangle** around one its sides through 360°.
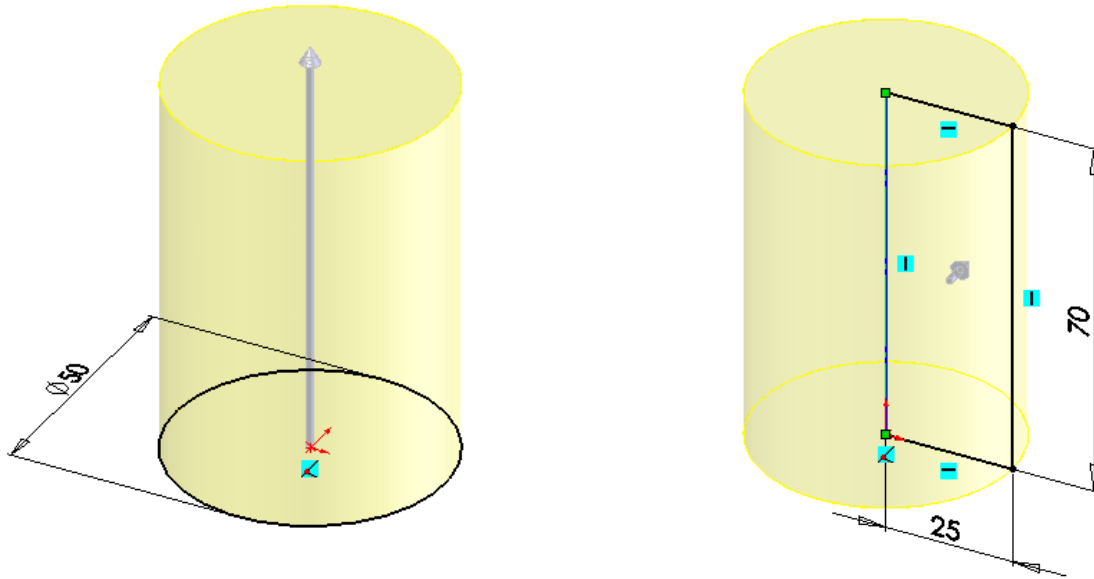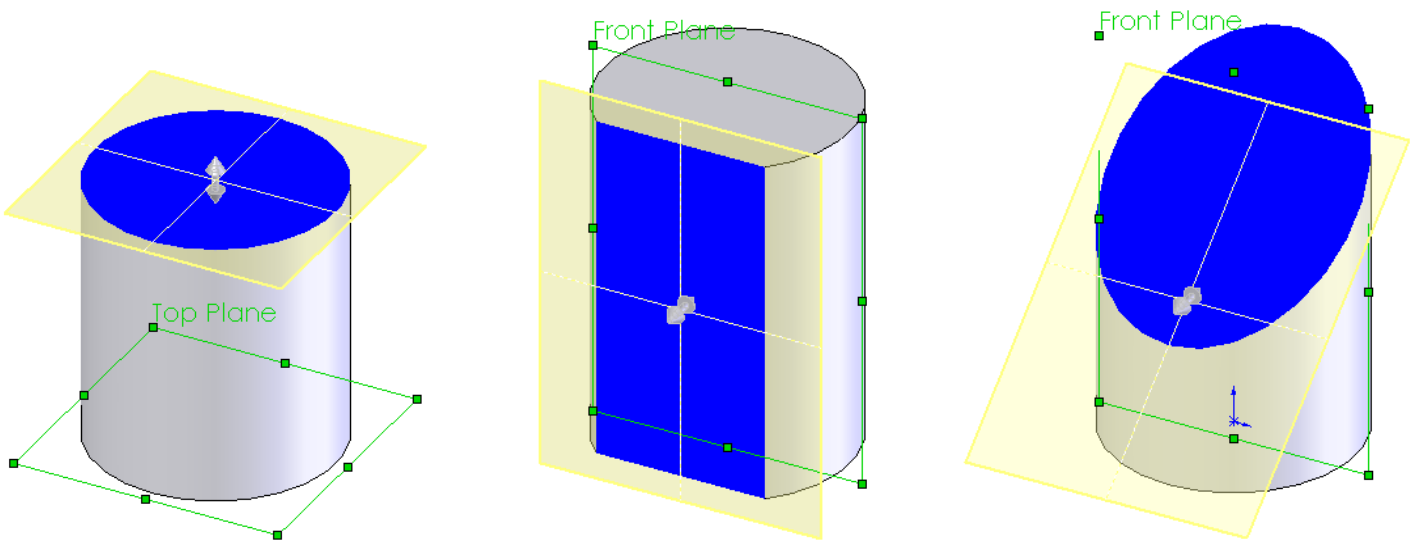
Sections of a Cylinder

If a cutting plane is perpendicular to the axis of a solid the resulting section is called a **cross-section**.

All cross-sections of a cylinder are circles (below left).

When the section plane is parallel to the axis the section is rectangular (below middle).

When the section plane is inclined to the axis as shown (below right) the section is an ellipse.

We can use a section plane positioned parallel to the axis of a cylinder to determine the plan of a point on its surface when given the elevation of the point. (SW MODEL)

The Cylinder and Sphere in Contact

If a **sphere** is in contact with a **cylinder**, the line joining the point of contact and the centre of the sphere will be perpendicular to the element of the cylinder that contains the point of contact.

The sketch across shows a **cylinder** and **sphere** in mutual contact. The projection on the V.P. illustrates the key principle.

The sphere is tangential to the extreme element of the cylinder and the horizontal plane.
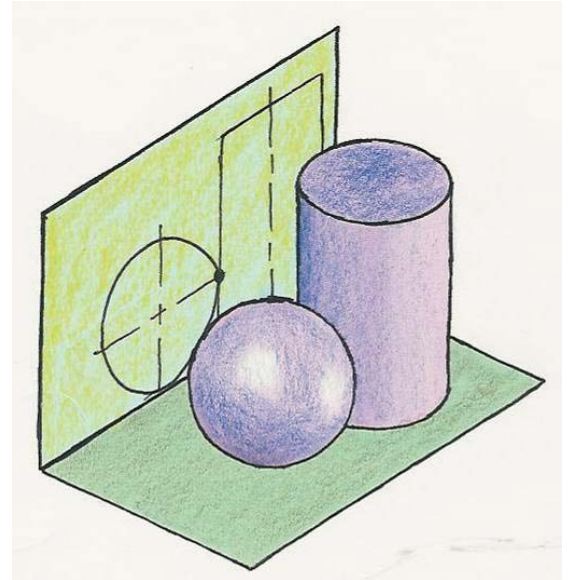
Students should be able to:

- Determine the projections of a sphere of given radius which shall touch a given cylinder at a given point

- Determine the projections of a sphere of given radius which shall touch a given cylinder and rest on the H.P.

- Determine the projections of a given cone, sphere and cylinder which rest on the H.P. in mutual contact
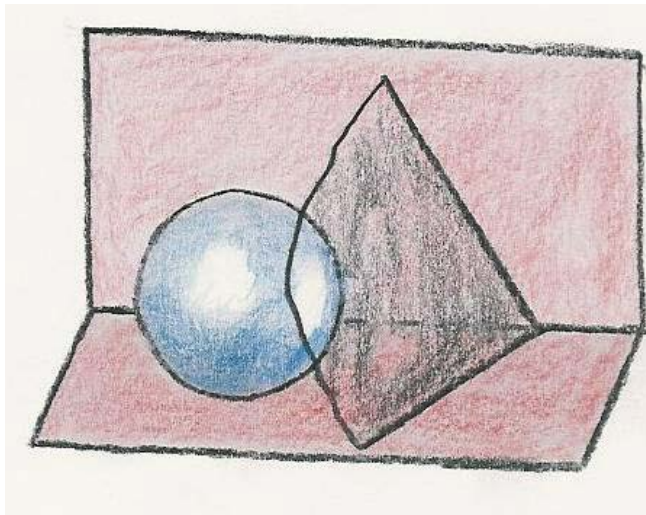
Tangent Planes

A tangent plane is a plane which touches a solid at a point or line of contact. This section will be confined to planes that can be drawn tangential to a cylinder, a cone and a sphere. These are called tangent planes.

A plane that is tangent to a ruled surface such as a cylinder or a cone contains one straight-line element of that ruled surface. Thus, there will be a line of intersection between a tangent plane and a cylinder or cone.

A plane that is tangent to a double-curved surface such as a sphere contains only one point in that surface. Thus, there will be a point of intersection between a tangent plane and a sphere.

Tangent Plane to a Sphere

A plane tangent to a sphere is perpendicular to the radius drawn to the point of tangency.

Students should be able to:

- Determine the traces of a tangent plane to a given cylinder at a given point on its surface

- Determine the traces of a plane which shall be tangential to a sphere at a given point on its surface

- Determine the traces of a plane which shall be tangential to a given cone at a given point on the surface of the cone

- Determine the traces of a plane which shall be tangential to a given cone and contain a given point outside the surface of the cone

- Determine the traces of a plane which shall be tangential to a cone and parallel to a given line

- Determine the traces of a plane which shall be tangential to a given cone and a given sphere

- Determine the traces of a plane to touch two given spheres and have a given inclination to the H.P.

- Determine the traces of a plane to contain a given line and touch a given sphere

- Determine the traces of a tangent plane common to two spheres in mutual contact