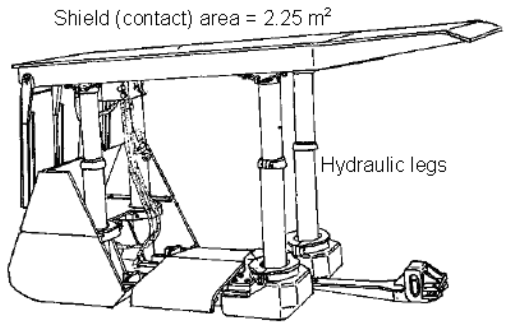
**MAD260-MINING I**
**PROBLEM SOLUTIONS**

**Question-** Four-legged sield type support units are usec support strata in a longwall mining process. If yielding strength of the support unit is 90 tonnes/leg and shield (contact) area of each unit is 2.25 $m^2$, determine the maximum depth of overburden to achieve supporting with a safety factor of 1.8 (Assume vertical pressure is a function of depth as $P_v = z\gamma$ where z is depth and $\gamma$ is unit weight of strata=2 g/$cm^3$).




**Answer**

For four legged unit, capacity = 90 t/leg*4 legs = 360 tonnes
Support density = 360 / 2.25 = 160 t/$m^2$
For safety factor, max.support density = 160 / 1.8 = 88.9 t/$m^2$

For equilibrium, $P_v$= max.support density = $z\gamma$,    then max.depth, z = 88.9/2 = 44.45 m.

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**Question-** A massive ore has a tonnage factor of 0.2 $m^3$/t. The ore contains 20% Galena, 30% Sphalerite and 50% Pyrite by weight. If the specific gravities of Galena and Sphalerite are 7.5 and 4.2 respectively, determine the specific gravity of Pyrite.

**Answer**

Unit weight of ore = 1/0.2 = 5 t/$m^3$ ➔ Specific gravity of ore = 5

<u>If % by weight</u> (Assume 100 tonnes of ore)
20/7.5+30/4.2+50/X=100/5 ➔ X=50/(20-2.67-7.14) ➔
X (SG of Pyrite) = 50/10.19 = **4.90**

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**Question-** A material's volume increases 40% when it is loosened. If 1.3 $m^3$ of loose material weights 2200 kg, determine;

a) Swell factor of the material
b) Loose unit weight, in gr/$cm^3$
c) Bank unit weight, in gr/$cm^3$

**Answer**

**a.** Swell Factor = 100/(100+%of swell) = 100/140 = **0.714**    or
Swell Factor = (100+%of swell)/100 = 140/100 = **1.4**
**b.** Loose unit weight = 2200 kg/1.3 $m^3$ = 1692 kg/$m^3$ = 1.692 t/$m^3$ = **1.692 g/$cm^3$**
**c.** If SF<1 then Bank unit weight = Loose unit weight / SF = 1.692 g/$cm^3$ / 0.714 = **2.37 g/$cm^3$**
If SF>1 then Bank unit weight = Loose unit weight * SF = 1.692 g/$cm^3$ * 1.4 = **2.37 g/$cm^3$**

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**Question-** Bank specific weight of a material is 3.0 g/$cm^3$. If 0.8 $m^3$ of loose material weights 2000 kg, determine swell factor and percent swell of the material.

**Answer**

Loose specific weight = (2000*1/0.8) = 2500 kg/$m^3$ = 2.5 gr/$cm^3$
Swell Factor (SF) = Bank Sp.W./Loose Sp.W. = 3.0/2.5 = **1.2**    or    2.5/3.0=**0.83**
Swell percentage = 100*SF-100 = 100*1.2-100 = **20%**

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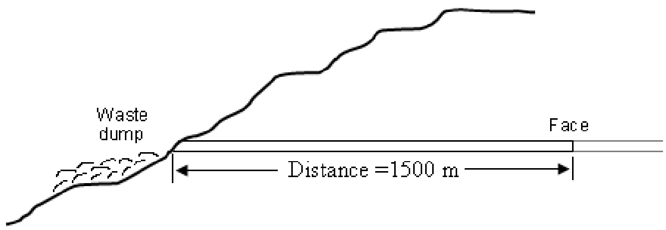
**Question-** A horizontal adit with a 4 $m^2$ face excavation area is driven as shown. A locomotive is run to carry the broken material to the surface. If the followings are given, determine the amount of advance per cut.




Intact (bank) rock density : 2.2 g/$cm^3$
Car weight : 1000 kg.
Number of cars : 4
Locomotive weight : 2500 kg.
Locomotive power : 20 HP
Loaded travel time : 10 min.
Friction coefficient on rail : 0.02
Motor efficiency : 80%

**Answer**

V=1500/10*60=2.5 m/s
N=(ΣF.V) / (75.η) ➔ ΣF=20*75*0.8/2.5=480 kg.
$\Sigma F = (\mu \pm i)\ [W_g + n(W_w+W_f)]$ ➔ $480=0.02[2500+4(1000+W_f)]$ ➔
Total material for four cars $4W_f=(480*50-6500)=17500$ kg
17500 kg/2200 kg/$m^3$=7.95 $m^3$
4 $m^2$*L=7.95 $m^3$ ➔ L (advance per cut) =7.95/4=1.99 m

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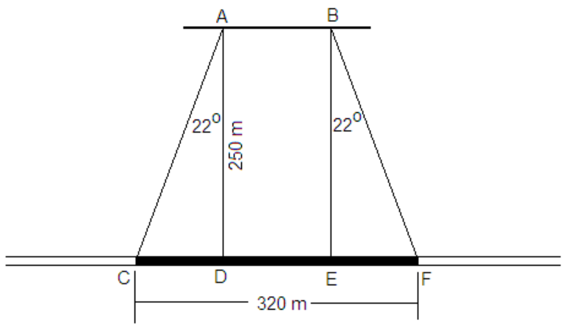
**Question-** A circular pillar is left in underground to protect an area at the surface. The coal seam is horizontally bedded at 250 m below surface. If diameter of the pillar is 320 m and the angle of draw is 22°, determine size of protected area in $m^2$ (thickness of seam is ignored).




**Answer**

CD = ADxtan 22° = 250xtan 22° = 101 m = EF
AB = DE = 320 - 2x110 = 118 m (diameter of protected area at the surface, circular)
Area of protected shape = $\pi r^2 = \pi(118/2)^2 = 10935\ m^2$

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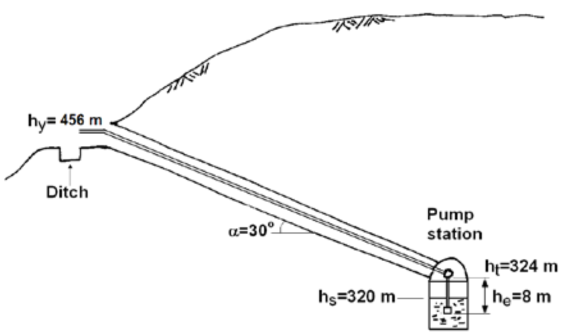
**Question-** A sump located in underground is used to pump mine water via an inclined drift. For givens, determine the pipe diameter to run the system. (Neglect fitting losses).




Pipe diameter : ? cm.
Water speed in pipe : 1.8 m/s
Gravity : 9.81 m/$s^2$
Efficiency : 80%
Friction factor of pipe : 0.02
Water flow rate : 1.2 l/s
Pump power : 3 HP

**Answer**

N=(Q.ΣH.γ) / (75.η) ➔ ΣH=(3*75*0.8)/(0.0012*1000)=150 m
$\Sigma H=\Delta H+H_s$ (fitting loss is neglected) ➔ $150=(h_y-h_s)+H_s$ ➔ $H_s = 150 – (456-320) = 14$ m
$L = [(h_y-h_t)/\sin\alpha] + h_e= [(456-324)/\sin 30] + 8= 272$ m
Friction loss, $H_s=[(\lambda.V^2.L)/(2.g.D)]= [(0.02*1.6^2*272)/(2*9.81*D)]= 14$ m
$D = [(0.02*1.2^2*272)/(2*9.81*14)] = 17.62/274.68 = 0.064$ m = 6.4 cm

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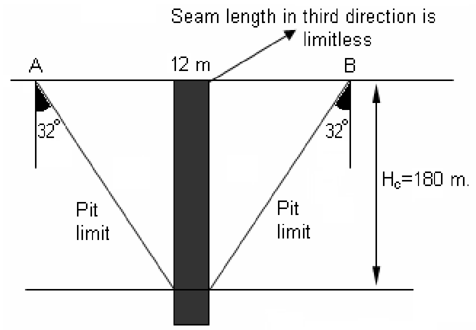
**Question-** A vertical ore seam with an uniform thickness of 12 meter is mined. If the figure and parameters are given, determine the stripping cost in TL/$m^3$. Consider that 180 m is the critical depth to mine by surface mining method.




| | |
|---|---|
| Open pit mining cost | : 16 TL/t |
| Underground mining cost | : 35 TL/t |
| Critical depth | : 180 m |
| Density of coal | : 1.3 g/$cm^3$ |

**Answer**

Critical Stripping Ratio = (Underground cost-Open Pit Cost) / Stripping Cost
According to costs, SR will be $m^3$/t (= (TL/t)/(TL/$m^3$). That means $m^3$ waste/tonnage of coal
To determine the coal and waste amount, we assume any length in the 3rd direction. Ex. 1 m.

Coal volume = 180*12*1 = 2160 $m^3$
Coal weight = 2160 $m^3$*1,3 t/$m^3$ = 2808 tonnes
Waste volume = 180*180*tan32°*1 = 20245 $m^3$
SR = 20245 $m^3$/2808 t = 7.21 $m^3$/t
7.21 $m^3$/t = (35-16 TL/t) / Stripping Cost ➔
Stripping Cost = (19 TL/t) / 7.21 $m^3$/t = 2.64 TL/$m^3$

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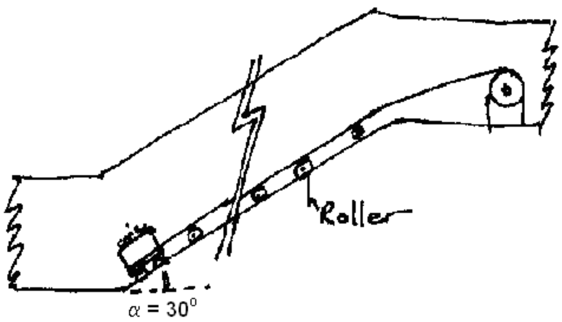
**Question-** A car hoisting system is running on an inclined drift as shown in the figure. Determine required motor power (HP) to run the system.

| | |
|---|---|
| Waste weight in car | : 2000 kg. |
| Car empty weight | : 750 kg. |
| Slope | : 30° |
| Road distance | : 120 m. |
| Traction coefficient | : 10 kg/t |
| Friction on rollers | : 0.2 |
| Hoisting speed | : 1 m/s |
| Motor efficiency | : 80% |
| Rope weight | : 0.45 kg/m |




**Answer**

Static weight, $W = W_b + W_t$ = 2000+750 = 2750 kg
$W_x = W.\sin\alpha$ = 2750*sin 30 = 1375 kg
$W_y = W.\cos\alpha$ = 2750*cos 30 = 2382 kg = 2.38 t
Traction force, $F_s = T.W_y$ = 10*2.38 = 23.8 kg
Forces due to traction and material, $F = W_x+F_s$ = 1375+23.8 = 1398.8 kg
Froces due to rope weight and friction on rollers;

$F_r = q.S.\sin\alpha + q.S.\cos\alpha.\mu$ = 0.45*120*sin 30+0.45*120*cos 30*0.2 = 27+9.4 = 36.4 kg

Total force, $\Sigma F = F+F_r$ = 1398.8+36.4 = 1435.2 kg
Motor power, $N=(\Sigma F.V) / (75.\eta)$ = (1435.2*1)/(75*0.8) = 23.9 HP or 23.9*0.75 = 18 kW

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**Question-** Rectangular pillars, 4 mx6 m in dimensions, are left to support and the rest is mined. If the extraction percentage (ratio) is 80%, determine the ifluence area of a singular pillar.

**Answer**

the influence area of a pillar is equal to whole area as well
e (extraction ratio) = excavated area / whole area = (whole area-pillar area) / whole area
then, 0.8=(x-(4*6)) / x ➔ x = 24/(1-0.8) = 120 $m^2$

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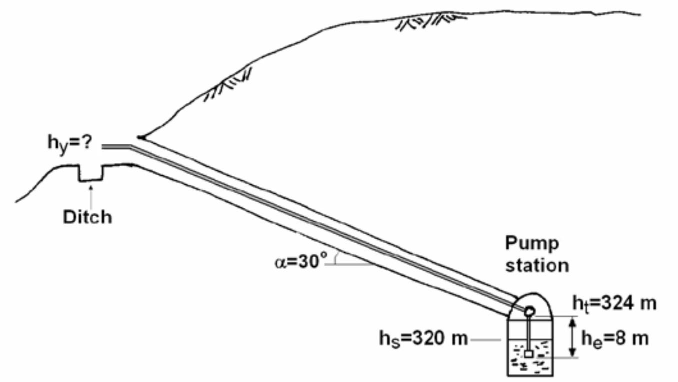
**Question-** A sump will be located in underground to pump mine water via an inclined drift. For givens, determine the elevation at discharge point ($h_y$). (Ignore fitting losses).

| | |
|---|---|
| Pipe diameter | : 5 cm. |
| Water speed in pipe | : 1.6 m/s |
| Gravity | : 9.81 m/s$^2$ |
| Efficiency | : 80% |
| Friction factor of pipe | : 0.02 |
| Water flow rate | : 1.2 l/s |
| Pump power | : 4 HP |




**Answer**

$N=(Q.\Sigma H.\gamma) / (75.\eta)$ ➔ $\Sigma H=(4*75*0.8)/(0.0012*1000)=200$ m

Friction loss, $H_s=[(\lambda.V^2.L)/(2.g.D)]= [(0.02*1.6^2*L)/(2*9.81*0.05)]=0.0522L$

Pipe length, $L = [(h_y-h_t)/\sin\alpha] + h_e= [(h_y-324)/\sin 30] + 8 = 2h_y-648+8 = 2h_y-640$

$\Sigma H=\Delta h+H_s$ (fitting loss is ignored) ➔ $200 = (h_y-h_s)+0.0522L$ ➔

$200=(h_y-320)+0.0522(2h_y-640)= h_y+0.1044h_y-33.41-320$ ➔

$1.1044h_y=200+353.41$ ➔ $h_y=553.41/1.1044=501.1$ m

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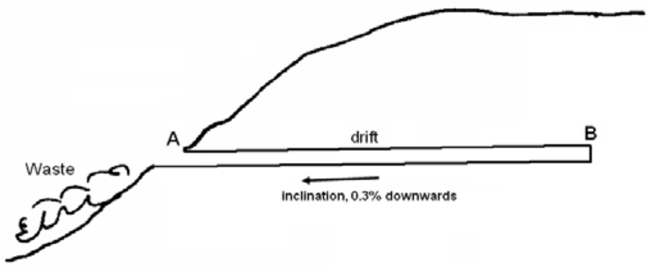
**Question-** A mine drift with a cross-sectional face area of 12 m$^2$ is driven upwards with an inclination (grade) of 0.3%. The broken material is hauled by a locomotive. For information given below, determine the amount of advance per round. Assume cars are full with their capacities.

Unit weight of Intact (bank) rock; 2 g/cm$^3$
Car empty weight; 800 kg.
Locomotive weight; 2500 kg.
Locomotive velocity (loaded); 6 m/sec
Friction coefficient on rail; 0.01
Number of cars; 6
Locomotive motor power; 30 HP
Motor efficiency; 80%




**Answer**

30 HP = ($\Sigma$F*6 m/s) / (75*0.8) ➔ $\Sigma$F=300 kg
300 kg= (0.01-0.003) [2500+6(800+x)] ➔ 6x = (300/0,007)-2500-4800 then
6x = 35557 kg (Total amount of material hauled after per advance in drift)
Volume = 35557/2000 = 17.78 m$^3$ (volume of hauled material)
Advance = 17.78/12 = 1.48 m. advance per round

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**Question-** A horizontal (flat) coal seam with a constant thickness of 4 m is situated 200 m below surface. A pillar of coal in square shape (top view) is left to protect the shaft and the surface area around the shaft. The amount of coal left in pillar is 360000 m$^3$. Angle of draw is 20$^o$. Determine the size of the area protected at the surface. (Use analytical solution).

**Answer**

Pillar area = 360000/4 = 90000 m$^2$ Pillar size (square) = $(90000)^{1/2}$ = 300 m.
Size at surface = 300-2*200*tan20$^o$ = 154.4 m (side of square arae protected at the surface)
Protected area = 154.4*154.4 = 23843 m$^2$

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**Question-** A horizontal mine drift with a cross-sectional face area of 10 $m^2$ is driven and the broken material is hauled by a locomotive. For information given below, determine the maximum amount of material (in kg or tonnes) can be carried by each of the cars.

Unit weight of Intact (bank) rock; 2 $g/cm^3$
Car empty weight; 700 kg.
Locomotive weight; 2500 kg.
Locomotive velocity (loaded/unloaded); 3 m/sec
Friction coefficient on rail; 0.01
Number of cars; 6
Locomotive motor power; 10 HP
Motor efficiency; 80%

**Answer**

10 HP = ($\Sigma$F*3 m/s) / (75*0.8) ➔ $\Sigma$F=(10*75*0.8)/3 = 200 kg
200 kg= (0.01) [2500+6 (700+x)] ➔ 6x = (200/0.01)-2500-4200 then
6x = 13300 kg (Total amount of material carried at once)
Capacity of per car = 13300/6 = 2216 kg

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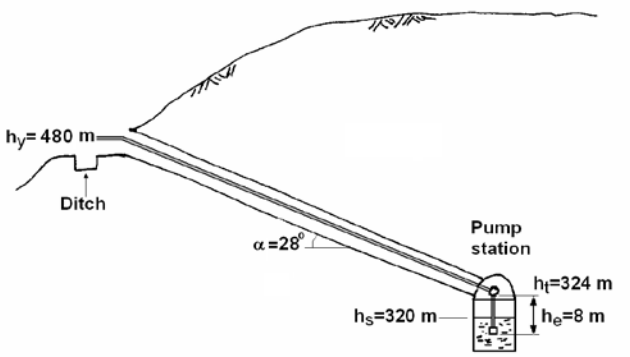
**Question-** A sump will be located in underground to pump mine water via an inclined drift. For given parameters, determine the pump power. (Ignore fitting losses).

| | |
|---|---|
| Pipe diameter | : 5 cm. |
| Water speed in pipe | : 1.2 m/s |
| Gravitational acc. | : 9.81 $m/s^2$ |
| Efficiency | : 75% |
| Friction factor of pipe | : 0.02 |
| Water flow rate | : 3.4 l/s |




**Answer**

$\Delta h = [(h_y-h_s) = 480-320 = 160$ m  L = $(h_y-h_t)/\sin 28^o+8 = 156/\sin 28^o+8 = 340$ m
If we ignore fitting losses,
$\Sigma H = \Delta h + [(\lambda.V^2.L)/(2.g.D)] = 160 + 0.02*1.2^2*340/2*9.81*0.05 = 160+9.98$ m = 170 m
Pump Power, $N=(Q.\Sigma H.\gamma) / (75.\eta) = 170*3.4*10^{-3}*1000/(75*0.75) = 10.3$ HP

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**Question-** 760 kg of a loose material occupies a volume of 0.8 $m^3$. Determine bank unit weight of this material if its swell percentage is 40 percent by volume.

**Answer**

Loose unit weight = 760/0.8 = 950 kg
Swell factor = 1.4 = Bank U.W./Loose U.W. then
Bank Unit Weight = 950*1.4 = 1330 $kg/m^3$ = 1.33 $g/cm^3$

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**Question-** In a room-and-pillar mininng, rectangular pillars of 4 mx6 m in dimensions are left to support and the rest of the seam is mined. If the influence area of a single pillar is 96 $m^2$ determine extraction percentage (ratio).

**Answer**

the influence area of a pillar is equal to whole area as well
e (extraction ratio) = excavated area / whole area
then, e = (96-24)/96 = 75%