AP® Physics 1
Super Review Packet

KEY

To Do

- ~~Upload AP folder to I~~
- APC Practice....
- APC Quiz
- AP1 Rec 2 Test Copies
- Talk about Review
- AP Videos

MECHANICS (Kinematics, Forces, Circular Motion, Momentum, Energy, Springs/Pendulums)

One-Dimensional Motion

List important equations (kinematics):

$$V = V_o + \bar{a}t$$
$$X = X_o + V_o t + \frac{1}{2}\bar{a}t^2$$
$$V^2 = V_o^2 + 2\bar{a}(x - x_o)$$

(Remember, there is more than one way to skin a cat. These are some but not all of the kinematic approaches to motion)

1. When you want to find how fast something is going or (final velocity)

a. given uniform acceleration, initial velocity, and time use- $V = V_o + \bar{a}t$

Ex: If a car starts at rest and accelerates at 4m/s^2 for a period of 30s, how fast is it now traveling?

$V = V_o + \bar{a}t$ $\quad V_o = \emptyset$ $\quad V = (4 m/s^2)(30 s) = \boxed{120 m/s}$

b. given initial velocity, acceleration, and displacement use- $V^2 = V_o^2 + 2\bar{a}(X - X_o)$ → Treat this as ΔX

Ex: A car starts from rest and accelerates at 4m/s^2 over a distance of 500m, how fast is it now traveling?

$V_o = \emptyset$ $\quad V^2 = 2(4)(500)$ $\quad \boxed{V = 63.2 m/s}$

2. When you want to find displacement

a. given initial velocity, final velocity, and time use- $X = X_o + V_o t + \frac{1}{2}\bar{a}t^2$ and $V = V_o + \bar{a}t$

Ex: A rocket starts from rest and accelerates uniformly to a speed of 250m/s in 6s. How far did the rocket travel?

$X_o = \emptyset$ $\quad V_o = \emptyset$ $\quad X = \frac{1}{2}\bar{a}t^2$ $\quad$ sub $\quad \bar{a} = \frac{V - V_o}{t}$

$X = \frac{1}{2}\left(\frac{V - V_o}{\cancel{t}}\right)t^{\cancel{2}}$

$X = \frac{1}{2}(V - V_o)t = \boxed{750 m}$

b. given initial velocity, acceleration, and time use- $X = X_o + V_o t + \frac{1}{2}\bar{a}t^2$

Ex: A car is traveling at 15m/s. The car accelerates at 3m/s^2 for 7s to pass another vehicle. How far did the car travel during this time period?

$X_o = \emptyset$ $\quad X = V_o t + \frac{1}{2}\bar{a}t^2 = \boxed{178.5 m}$

Ex: A stone is dropped from rest and is in free fall for 3s. How far did the stone fall?

$a = -g$ $\quad V_o = \emptyset$ $\quad y = y_o + \cancel{V_o t} - \frac{1}{2}gt^2$ $\quad \Delta y = -\frac{1}{2}gt^2 = \boxed{44.1 m}$

c. given final velocity, initial velocity, and acceleration use- $V^2 = V_o^2 + 2a\Delta X$

Ex: How high does a rock thrown upward with an initial velocity of 30m/s travel?

$a = -g$ $\quad V^2 = V_0^2 - 2g\Delta y$ $\quad \emptyset = V_0^2 - 2g\Delta y$

$V = \emptyset$

$\frac{-V_0^2}{-2g} = \Delta y = \boxed{45.9m}$

3. When you want to find acceleration

a. given final velocity, initial velocity and time use- $\bar{a} = \frac{V - V_0}{t}$

Ex: What is the average acceleration of a car that goes from rest to 10m/s in 8s?

$V_0 = \emptyset$ $\quad \bar{a} = \frac{V - V_0}{t} = \boxed{1.25 m/s}$

b. given final velocity, initial velocity and displacement use- $V^2 = V_0^2 + 2a\Delta X$

Ex: What is the acceleration of an object that starts from rest and travels uniformly to 15m/s over a distance of 10m? $V^2 = V_0^2 + 2a\Delta X$ $\quad \bar{a} = \frac{V^2 - V_0^2}{2\Delta X} = \boxed{11.3 m/s}$

$V_0 = \emptyset$

4. When you want to find time

a. given initial velocity, acceleration, and displacement use- $x = x_0 + v_0 t + \frac{1}{2}at^2$

Ex: A stone is dropped from a 50m high building. How long is the stone in free fall?

$V_{oy} = \emptyset$ $\quad \Delta y = \cancel{V_{oy}t} - \frac{1}{2}gt^2$ $\quad t = \sqrt{\frac{2\Delta y}{-g}} = \boxed{3.19s}$

$a = -g$ $\quad \Delta y = -50m$

b. given initial velocity, final velocity and acceleration use- $V = V_0 + \bar{a}t$

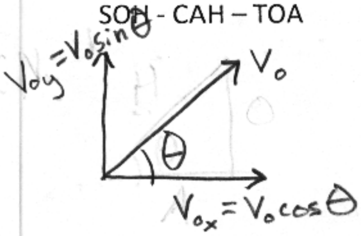
Ex: A ball is thrown upward with an initial velocity of 10m/s, how long does it take the ball to reach its highest point? $V_0 = 10m/s$ $\quad a = -g$ $\quad \emptyset = V_0 - gt$

$V = \emptyset$ $\quad \frac{-V_0}{-g} = t = \boxed{1.02s}$

<u>Two Dimensional Motion (Projectiles)</u>

All equations in 2-D motion are kinematics, they just have angles now!

SOH - CAH – TOA



Projectiles

[redacted]:

x-axis	y-axis
$\Delta X = V_{ox} \cdot t$	$V_y = V_{oy} - gt$
	$\Delta y = V_{oy}t - \frac{1}{2}gt^2$
	$V_y^2 = V_{oy}^2 - 2g\Delta y$

Max height with θ:

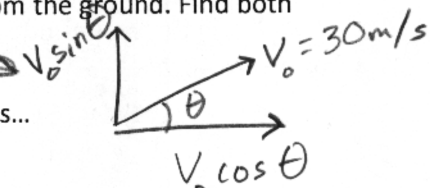
$V_y^2 = V_{oy}^2 - 2g\Delta y$ $\quad V_{oy} = V_0 \sin\theta$

$\emptyset = (V_0 \sin\theta)^2 - 2g\Delta y$ $\quad V_y = \emptyset$

$\boxed{\Delta y = \frac{(V_0 \sin\theta)^2}{2g}}$

1. A projectile is launched with an initial velocity of 30m/s at an angle of 30° from the ground. Find both the x-component and y-component of its initial velocity.

$\boxed{V_{oy} = 15 m/s}$ $\quad \boxed{V_{ox} = 26 m/s}$



2. When a projectile is launched (no air friction) describe what is occurring to its...

horizontal velocity stays constant.

vertical velocity changes due to a downward acceleration of (g)

Horizontal velocity- constant

Vertical velocity- changing

Acceleration- constant $(-g)$ only y-axis

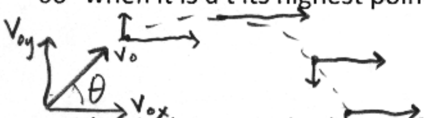
3. So if the x and y components of velocity are independent tell me ...

a. How long it takes a rock thrown at 6m/s horizontally off a cliff to fall 15m?

$h = 15m$ $\quad \Delta y = \cancel{V_{oy}t} - \frac{1}{2}gt^2$

$V_{oy} = \emptyset$ $\quad h = \frac{1}{2}gt^2 \quad t = \sqrt{\frac{2h}{g}} = \boxed{1.75_s}$

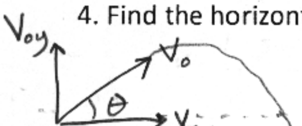
b. What is the horizontal velocity of a projectile launched with an initial velocity of 12m/s at an angle of 60° when it is a t its highest point? horizontal velocity is constant



$V_{ox} = V_o \cos\theta = \boxed{6 m/s}$

c. What is the vertical velocity of a projectile launched with an initial velocity of 12m/s at an angle of 60° when it is a t its highest point? At highest point $V_y = \emptyset$

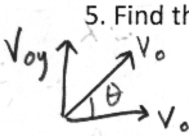
4. Find the horizontal distance that a projectile travels when launched at 50m/s from an angle of 30°.



$\Delta X = V_{ox} \cdot t$ $\quad V_y = V_{oy} - gt$ $\quad V_y$ @ highest point is zero

$\Delta X = V_o \cos\theta \cdot (5_s) = \boxed{216.5_m}$ $\quad t = \frac{V_{oy}}{g} = \frac{V_o \sin\theta}{g} = 2.5_s$ time half way up

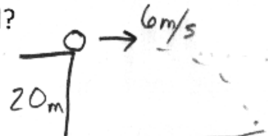
5. Find the maximum height of a projectile launched at 50m/s from an angle of 30°.



$V_{oy} = V_o \sin\theta$ $\quad \cancel{V_y^2} = V_{oy}^2 - 2g\Delta y$ $\quad \frac{(V_o \sin\theta)^2}{2g} = \Delta y = \boxed{31.3_m}$

$V_y = \emptyset$

6. If a projectile is launched horizontally at 6m/s off a 20m high cliff, how far horizontally from the base of the cliff will the projectile land?

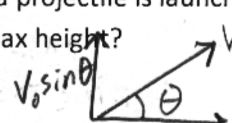


$\Delta X = V_{ox} \cdot t = \boxed{12m}$

$V_{oy} = \emptyset$

$V_{ox} = 6m/s$ $\quad t = \sqrt{\frac{2h}{g}} = 2_s$

7. If a projectile is launched at 45m/s from an angle of 60°, how long will it take the projectile to reach its max height?



$V_{oy} = V_o \sin\theta$ $\quad \cancel{V_y} = V_{oy} - gt$ $\quad t = \frac{V_o \sin\theta}{g} = \boxed{3.9_s}$

$V_y = \emptyset$

<u>Questions that should be done with out formula chart. (Use 10m/s² for g)</u>

Kinematics

1. What is the magnitude of the velocity after 1.5 seconds of a ball thrown upward from a height of 5m at 40m/s?

Cliff is meaningless

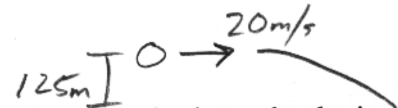
$V = V_o - gt$

$t = 1.5_s$

$a = -g$

$V_o = 40m/s$

$V = 40 - (10 \cdot 1.5) = \boxed{25m/s}$



2. An object is thrown with a horizontal velocity of 20m/s from a cliff that is 125m above ground level. If air resistance is negligible, the time that it takes the object to fall to the ground from the cliff is most nearly…

time is only dependent on y-axis $\quad V_{oy} = \emptyset$

$\Delta y = \cancel{V_{oy}t} - \frac{1}{2}gt^2 \quad h = \frac{1}{2}gt^2 \quad t = \sqrt{\frac{2h}{g}} = \boxed{5_s}$

3. The rate of change of velocity is the definition of...

acceleration $\quad \bar{a} = \frac{\Delta V}{\Delta t}$

4. A rock is thrown horizontally off a building. The speed of the rock as it leaves the thrower's hand at the edge of the building is v. It takes an amount of time, t, to travel from the edge of the building to the ground. How far from the side of the building, measured horizontally, does the rock land? (answer in terms of g,v, and t) $\quad O \rightarrow V \quad t \quad \boxed{\Delta x = Vt}$

5. An object is thrown straight upward. Describe the velocity and acceleration at the moment the object is at its highest point. accelerating downward @ "g"

☆ Part 1 6. A truck on a straight road starts from rest accelerating at $2m/s^2$ until it reaches a speed of 30.0 m/s. It ~~then~~ applies its brakes and comes to a stop in 8.0 s. What total distance does the truck cover during the total period of motion described here?

$V_o = \emptyset \quad V^2 = V_o^2 + 2a\Delta X \quad \Delta X = \frac{V^2}{2a} = 225_m$

Part 2 $\quad V_o = 30m/s \quad V = \emptyset \quad X_o = 225_m \quad t = 8_s \quad a = \frac{V - V_o}{t} = -3.75\,m/s^2$

$X = X_o + V_o t + \frac{1}{2}at^2 = \boxed{345_m}$

7. A rock is thrown straight downward at 10m/s from a height of 3.5 m. How long does it take the rock to reach the ground?

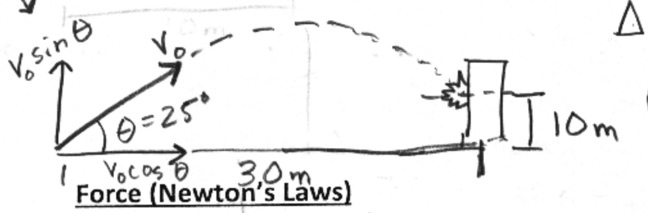
$V_{oy} = -10m/s \quad \Delta y = -3.5m \quad \Delta y = V_{oy}t - \frac{1}{2}gt^2$ "quadratic"

$-3.5 = -10t - 5t^2$

$\emptyset = -5t^2 - 10t + 3.5$

$\boxed{t = 0.3_s}$

Hard 8. A ball is thrown upward at an angle of 25 degrees above the horizontal. It passes its maximum height, then strikes a wall 30m away from its starting position at a height of 10m above its starting height. What was the ball's initial velocity?



$\Delta y = 10m \quad \theta = 25° \quad \Delta X = 30m$

$\Delta X = V_{ox} \cdot t \quad \Delta X = V_o \cos\theta \cdot t \quad t = \frac{\Delta X}{V_o \cos\theta}$

$\Delta y = V_{oy} t - \frac{1}{2}gt^2$

$\Delta y = \cancel{V_o} \sin\theta\left(\frac{\Delta X}{\cancel{V_o}\cos\theta}\right) - \frac{1}{2}g\left(\frac{\Delta X}{V_o\cos\theta}\right)^2$

$\Delta y = \tan\theta\,\Delta X - \frac{1}{2}g\frac{\Delta X^2}{(V_o\cos\theta)^2}$

$\frac{1}{2}g\frac{\Delta X^2}{(V_o\cos\theta)^2} = \tan\theta\,\Delta X - \Delta y$

$V_o^2\cos^2\theta = \frac{g\,\Delta X^2}{2(\tan\theta\,\Delta X - \Delta y)}$

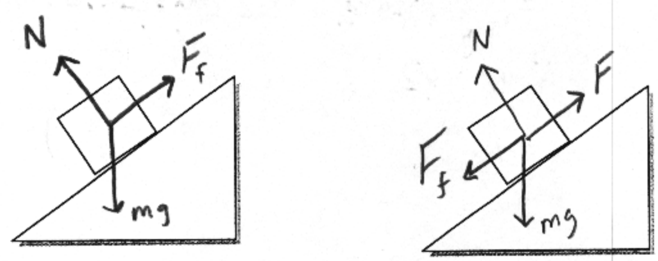
$V_o = \sqrt{\frac{g\,\Delta X^2}{2\cos^2\theta(\tan\theta\,\Delta X - \Delta y)}}$

$\boxed{V_o = 37\,m/s}$

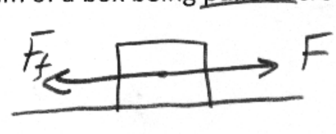
Force (Newton's Laws)

1st Law: 2nd Law: 3rd Law:

☆ Free body: A block at rest and a block being pushed up an incline. (with friction)



1. Draw a free body diagram of a box being pulled across a horizontal surface at a constant velocity.



What is the acceleration of the box? $a = \emptyset$ constant "V"

What is the net force acting on the box?

$\Sigma F = \emptyset$

2. A 50kg box is pushed across a frictionless horizontal surface with a force of 25N. If it starts from rest, how fast is it traveling after it has been pushed 35m? (Use 2nd law and kinematics)

$V_0 = \emptyset$ $\quad \Sigma F = ma \quad a = \frac{F}{m} = 0.5 m/s^2$

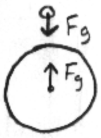
$\Delta X = 35m \quad F = ma$

$V^2 = \cancel{V_0^2} + 2a\Delta X$

$V = \sqrt{2(0.5)(35)} = \boxed{5.92 m/s}$

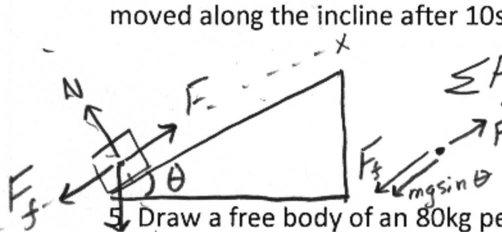
3. Give 2 examples of Newton's 3rd Law in action.

Force of Gravity on a orbiting satellite



A Rocket and it's exhaust

4. A box with a mass of 10kg is pushed up a 60° incline with an applied force of 200N parallel to the incline surface. If the coefficient of friction between the box and ramp is 0.3, how far will the block have moved along the incline after 10s?



$\Sigma F_x = ma$

$F - F_f - mg\sin\theta = ma$

$F - umg\cos\theta - mg\sin\theta = ma$

$a = \frac{F - umg\cos\theta - mg\sin\theta}{m} = 9.8 m/s^2$

$\Delta X = \frac{1}{2} a t^2$

$\boxed{\Delta X = 490m}$

5. Draw a free body of an 80kg person in an elevator accelerating upward at a rate of 3m/s². If the person is standing on a scale, how much does the scale read in newtons?

$\Sigma F = ma$

$N - mg = ma$

$N = ma + mg = \boxed{1,040N}$

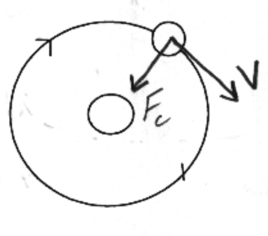
Circular Motion

List equations:

$\Sigma F_c = ma_c \quad V = \frac{2\pi r}{T} \quad F_g = G\frac{m_1 m_2}{r^2}$

$a_c = \frac{V^2}{r} \quad T = \frac{1}{f} \quad f = \frac{1}{T}$

1. Draw and label the tangential velocity, centripetal acceleration, and centripetal force vectors acting on the revolving object.

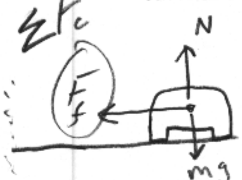


2. Describe how water stays in a bucket as it is spun in a vertical circle on Earth.

The water wants to move in the direction of it's current velocity. The bucket (centipetal force) forces it to chang direction continually. (Inertia)

3. Calculate the amount of centripetal force required to keep a 2000kg car from skidding during a 45m/s turn around a horizontal curve with a radius of 5.0m.

ΣF_c



$\Sigma F_c = m a_c$

$\Sigma F_c = m\frac{v^2}{r} = \boxed{8.1\times10^5 N}$

4. Find 2 objects in the room. Mass them and place them a set measured distance apart. Now calculate the theoretical gravitational force between the objects.

$m_1 = 2kg$ $r = 1.0m$ $F_g = G\frac{m_1 m_2}{r^2} = \boxed{6.67\times10^{-10} N}$

$m_2 = 5kg$

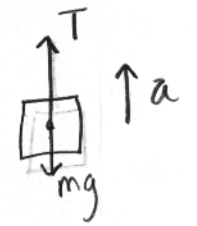
Super small!

$G = 6.67\times10^{-11} N\cdot\frac{m^2}{kg^2}$

Forces (Draw FBDs)

1. A rope of negligible mass supports a block that weighs 30N. The breaking strength of the rope is 50N. The largest acceleration that can be given to the block by pulling up on it with the rope without breaking the rope is most nearly…

$\boxed{a = 6.67 m/s^2}$ $T = 50N$ $m = 3kg$



$\Sigma F = ma$

$T - mg = ma$

$a = \frac{T - mg}{m}$

2. A new planet is discovered that has twice the Earth's mass and twice the Earth's radius. On the surface of this new planet, a person who weighs 500N on Earth would experience a gravitational force of…

$F_g = G\frac{mM}{r^2} = 1\frac{1\cdot2}{(2)^2} = \frac{2}{4} = \frac{1}{2}$ the gravity of Earth

$\boxed{F_g \text{ on Earth} = 1000N}$

3. What is the orbital speed of a satellite of mass m orbiting the earth at a distance r from the center of the Earth? (Assume that G stands for the gravitational constant and M stands for the Earth's mass.)

$\Sigma F_c = ma_c$ $F_g = G\frac{mM}{r^2}$ $G\frac{\cancel{m}M}{r^{\cancel{2}}} = \frac{\cancel{m}v^2}{\cancel{r}}$ $\boxed{v = \sqrt{\frac{GM}{r}}}$

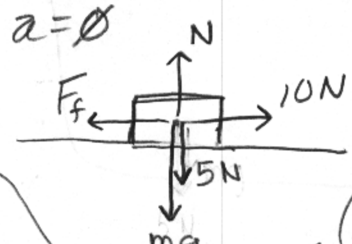
4. A child has a toy tied to the end of a string and whirls the toy above his head at a constant speed in a horizontal circular path of radius R. The toy completes each revolution of its motion in a time period T. What is the magnitude of the acceleration of the toy?

$a_c = \frac{v^2}{R}$ $v = \frac{2\pi R}{T}$ $a_c = \frac{(2\pi R)^2}{T}$

$\boxed{a_c = \frac{4\pi^2 R^2}{T}}$

5. A 2kg block slides with constant velocity along a horizontal tabletop. A horizontal applied force of 10N and a downward applied force of 5N act on the block, as shown. The coefficient of friction between the block and tabletop is most

$a = \emptyset$



$F_f = \mu N$

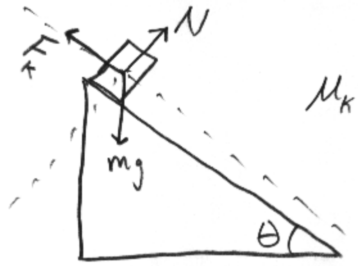
$\Sigma F_x = \emptyset$ $(10N) - F_f = \emptyset$

$\Sigma F_y = \emptyset$ $N - (5N) - mg = \emptyset$

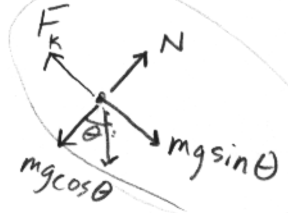
$N = mg + 5$

$(10N) = \mu(mg + 5)$

$\mu = \frac{10}{25} = \boxed{0.4}$



$\mu_k = 0.4$



$N = mg\cos\theta$

6. A 2kg object is released to slide down a 20° incline. If the coefficient of kinetic friction between the object and incline is 0.2 the object will accelerate down the incline at a rate of…

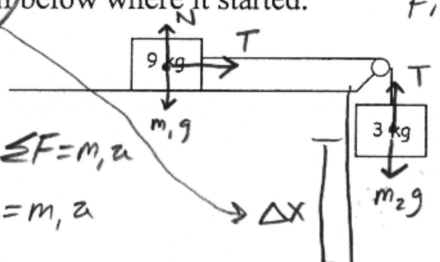
$\Sigma F = ma$

$\cancel{m}g\sin\theta - \mu\cancel{m}g\cos\theta = \cancel{m}a$

$a = g\sin\theta - \mu g\cos\theta = \boxed{1.54\,m/s^2}$

7. The two blocks in the picture are being held in place, and are then released from rest. Assume the table and pulleys are frictionless: the tension in the cord connecting the blocks, the acceleration of the 3kg block as it descends, and the speed of the 3kg block as it strikes the floor, 1.2m below where it started. Find

Find "a" first



$\Sigma F = m_1 a$

$T = m_1 a$

$\Sigma F = m_2 a$

$m_2 g - T = m_2 a$

$\cancel{T} + m_2 g - \cancel{T} = m_1 a + m_2 a$

$m_2 g = a(m_1 + m_2)$

$a = \dfrac{m_2 g}{m_1 + m_2} = \boxed{7.5\,m/s^2}$

$T = m_1 a = \boxed{67.5N}$

$v^2 = \cancel{v_0^2} + 2a\Delta x$

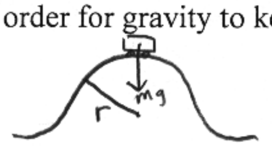
$v = \sqrt{2(7.5)(1.2)}$

$\boxed{v = 4.24\,m/s}$

8. A roller-coaster car has a mass of 600kg when fully loaded with passengers. The vehicle is approaching the top of a hill that is shaped like part of a circle of radius 20m. What is the maximum speed the car can have when it is at the top of the hill, in order for gravity to keep the car on the track?

Normal force shrinks to zero

$\Sigma F_c = ma_c$



$\cancel{m}g = \dfrac{\cancel{m}v^2}{r}$ $v = \sqrt{gr} = \boxed{109.5\,m/s}$

9. Use the given information in the table to determine the orbital speed of the Moon around the Earth, as well as the period of orbit of the Moon.

No sun

Body	Mass (kg)	Mean Radius (m)	Distance from Sun (m)
Earth (M)	5.98×10^{24}	6.37×10^{6}	1.496×10^{11}
~~Sun~~	~~1.991×10^{30}~~	~~6.96×10^{8}~~	--
Moon (m)	7.36×10^{22}	1.74×10^{6}	--

* Distance from the Earth to the Moon = 384,000 km

orbital speed

$\Sigma F_c = \dfrac{mv^2}{r}$

$F_g = G\dfrac{mM}{r^2}$

$G\dfrac{\cancel{m}M}{r^{\cancel{2}}} = \dfrac{\cancel{m}v^2}{\cancel{r}}$

$\boxed{v = \sqrt{\dfrac{GM}{r}}}$

Period

$G\dfrac{\cancel{m}M}{r^{\cancel{2}}} = \dfrac{\cancel{m}\left(\frac{2\pi r}{T}\right)^2}{\cancel{r}}$

$G\dfrac{M}{r} = \dfrac{4\pi^2 r^2}{T^2}$

$\boxed{T^2 = \dfrac{4\pi^2 r^3}{GM}}$

Energy

List Equations:

$K = \frac{1}{2}mv^2$

$U_g = mgh$

$U_s = \frac{1}{2}kx^2$

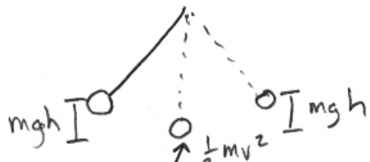
$K_0 + U_0 = K + U$

$W = \bar{F}\cdot d\cos\theta$

$W = \Delta K$

$P = \dfrac{W}{t} = \dfrac{\bar{F}\cdot d}{t} = \bar{F}\cdot\bar{v}$

1. Describe the conservation of mechanical energy using a pendulum as an example. $E = \text{constant}$



$E = K + U$

at any point $K + U = E$

2. How much work does a 60kg block raised 10m off the ground have the potential to do? (No air)

$-W_g = \Delta U_g$ $\quad -W_g = mgh - mgh_0$

$W_g = -6000J$ so... $\boxed{W = 6000J}$

a. What will be the change in the boxes kinetic energy during the fall?

$W = \Delta K \quad \Delta K = 6000J$

b. How fast will the box be traveling at the bottom?

$\cancel{m}gh = \frac{1}{2}\cancel{m}v^2 \quad v = \sqrt{2gh} = \boxed{14.14 m/s}$

3. In the previous scenario, do you need to know the mass of the object? Explain and demonstrate why or why not. No

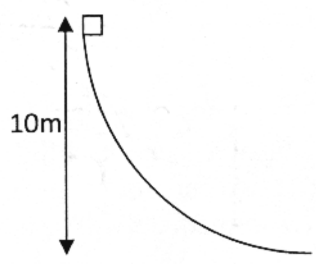
4. If I am rolling objects down two different θ inclines, what factor(s) determine the object's speed at the bottom of the incline. (no friction) Explain.

the vertical displacement and gravity only. gravity is a conservative force.

~~a. Who discovered this?~~

Galileo

5. A 50kg object slides down a decreasing slope as shown. At the bottom of the slope the object is traveling at 5m/s.



How much work was done by friction?

$\cancel{K_0} + U_0 + W_f = K + \cancel{U}$

$mgh + (W_f) = \frac{1}{2}mv^2$

$W_f = \frac{1}{2}mv^2 - mgh$

$\boxed{W_f = -4{,}375J}$

Momentum

List equations:

$p = mv$

$P_0 = P$

$m_1v_{1_0} + m_2v_{2_0} = m_1v_1 + m_2v_2$

$J = \Delta mv$

$J = F \cdot \Delta t$

m_1 V_{1_0} m_2

1. A 0.005kg projectile is traveling at 500m/s when it strikes an 80kg stationary target. If the projectile lodges itself in the object what is the velocity of the system after the collision?

perfectly inelastic

$m_1 V_{1_0} = (m_1 + m_2) V_f$

$V_f = \frac{m_1 V_{1_0}}{m_1 + m_2} = \boxed{0.031 m/s}$

a. So what's wrong with most Hollywood action films?

They show people flying back when the gun had almost no recoil!

2. A 60kg girl on ice skates throws a 5kg ball at 15m/s. What is the speed of the girl? (ignore friction)

m_1 m_2 V_2 explosion!

$P_0 = \emptyset$

$\emptyset = m_1 V_1 + m_2 V_2$

$\frac{-m_2 V_2}{m_1} = V_1$

$\boxed{-1.25 m/s}$

3. A 25kg toy car starts from rest and accelerates at $3m/s^2$ over a distance of 4m. How much momentum does the toy have at 4m?

$V_0 = \emptyset$

$a = 3m/s^2$

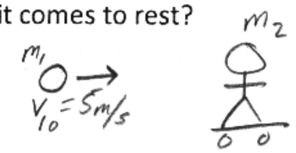
$\Delta X = 4m$

$V^2 = V_0^2 + 2a\Delta X$

$V = \sqrt{2(3)(4)} = 4.9 m/s$

$p = mv = \boxed{122.5 \ kg \cdot m/s}$

4. A 25kg medicine ball is tossed at 5m/s to a boy at rest on a magic frictionless skateboard whose combined mass is 60kg. The boy catches the ball and the skateboard begins to roll. The skateboard then loses its magic abilities and begins to experience a force of friction caused by a 0.3 coefficient between the wheels and the ground. How far will the skateboard roll from the moment is started to experience friction until it comes to rest?



COM Perfect inelastic

$m_1 V_{1_0} = (m_1 + m_2) V_f$

$V_f = \frac{m_1 V_{1_0}}{m_1 + m_2} = 1.47 m/s$ becomes $= V_0$

$V = \emptyset$

$W = \Delta K$

$\cancel{-} F_f \cdot d = \cancel{-} \frac{1}{2}(m_1 + m_2) V_0^2$

$\mu \cancel{(m_1 + m_2)} g \cdot d = \frac{1}{2} \cancel{(m_1 + m_2)} V_0^2$

$d = \frac{V_0^2}{2\mu g} = \boxed{0.36 m}$

Momentum, Energy and Work

1. A railroad car of mass m, moving at a speed v, collides with a second railroad car of mass M which is at rest. The two cars lock together and move along the track. What is the speed of the cars immediately after the collision?

$mv = (m+M)V_f$

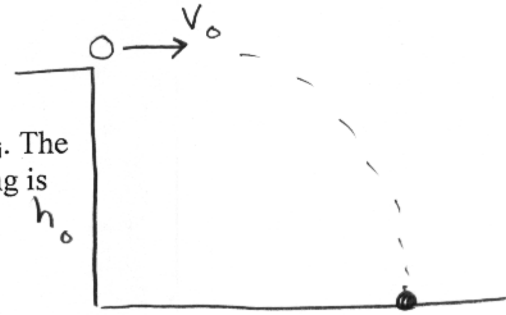
$\boxed{V_f = \frac{mv}{m+M}}$

2. According to the work-kinetic energy theorem, what must be true about an object if the net work done on it during some time interval is equal to zero?

$W = \Delta K$

$\emptyset = \Delta K$

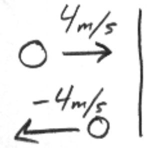
it did not change in kinetic enegy so speed stayed the same,



3. A rock of mass m is thrown horizontally off a building from a height h_i. The speed of the rock as it leaves the thrower's hand at the edge of the building is v_i. Disregarding air resistance, what is the kinetic energy of the rock just before it hits the ground?

$U_o + K_o = K + \cancel{U}$ $\boxed{K = mgh_o + \frac{1}{2}mv_o^2}$

4. A 5kg ball approaches a wall at a speed of 4m/s. It then bounces off of the wall in the opposite direction at the same speed. What is the magnitude of the average force exerted on the ball if it is in contact with the wall for 0.1s?



$t = 0.1s$
$m = 5kg$

$J = m(v - v_o) = -40 kg\cdot m/s$ $\frac{J}{\Delta t} = F_{avg}$ $\boxed{F = -400N}$

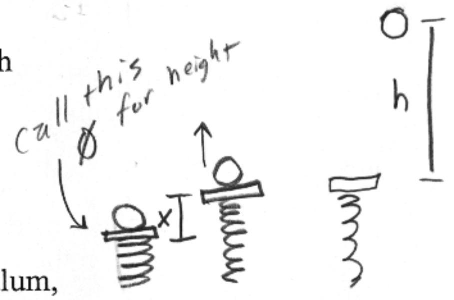
5. The two blocks of masses M, initially travel at the same speed v but in opposite directions. Momentum is conserved as they collide ~~and stick~~ together. How much mechanical energy is lost to other forms of energy during the collision?

$\text{M} \xrightarrow{v}$ $\xleftarrow{v} \text{M}$ $Mv - Mv = \emptyset$ COM

$Kinetic = \frac{1}{2}Mv^2 + \frac{1}{2}Mv^2 = \emptyset$

$\boxed{E_{lost} = Mv^2}$

6. A 50g ball is launched straight upward by a spring of spring constant 10 N/m. If the spring is initially compressed a distance of 15cm, use energy considerations to find the maximum height above its launch position to which the ball rises. (Note that the ball's launch position is where it leaves the spring, NOT at the spring's initial compressed position.)



At compression

$U_s = mg(h + x) \rightarrow \left(\frac{\frac{1}{2}kx^2}{mg} - x\right) = h = \boxed{0.075m \text{ or } 75cm}$

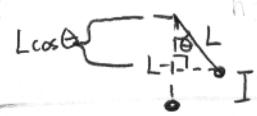
7. What is the launch velocity of a 100g ball fired into a 250g ballistic pendulum, if the 35cm-long pendulum reaches a maximum angle of 45degrees with the vertical, assuming the pendulum catches the ball when they collide?

$L = .35m$
$m = .1kg$
$M = .25kg$

Before $\xrightarrow{V_o}$ m, M, L — After 45, M+m, L, h

COM
$m_1 V_o = (m + M)V_f$

-After- COE
$\frac{1}{2}(m+M)V_f^2 = (m+M)gh$



$h = L - L\cos\theta$

$\frac{1}{2}(m+M)V_f^2 = (m+M)g(L - L\cos\theta)$

Find V_f

$V_f = \sqrt{\frac{2(m+M)(L - L\cos\theta)}{m+M}}$

$V_f = 0.45 m/s$

No find V_o

$V_o = \frac{(m+M)V_f}{m_1}$

$\boxed{V_o = 1.58 m/s}$

8. Starting from rest, a 20kg block slides down 4m along a frictionless ramp that is inclined at 20 degrees to the floor. Then the block slides another 3m along the flat, horizontal floor as it slows to a stop.

a. Calculate the work done by gravity as the ~~block slides~~ down the ramp.

$W_g = mgh = 20(10)1.37 = \boxed{274J}$

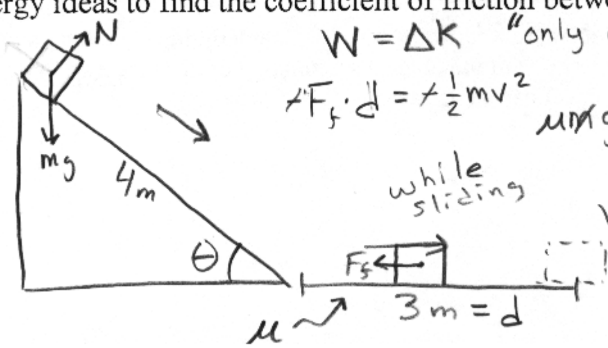
b. Use work and energy considerations to find the speed of the block at the base of the ramp. $W = \Delta K$

work is only done by gravity

$\cancel{m}gh = \frac{1}{2}\cancel{m}v^2$

$v = \sqrt{2gh} = \boxed{5.23 m/s}$

c. Use work and energy ideas to find the coefficient of friction between the block and floor.



$h = 4_m \sin\theta$
$h = 1.37_m$

$W = \Delta K$ "only work by friction"

$\cancel{-}F_f \cdot d = \cancel{-}\frac{1}{2}mv^2$

$\mu \cancel{m} g \cdot d = \frac{1}{2}\cancel{m}v^2$

while sliding

$\mu = \frac{v^2}{2gd}$

$V = \emptyset$

$\boxed{\mu = 0.46}$

2 Parts

FRQs

a) $a = 1.5\,m/s^2$

$V = 5\,m/s$ $\quad V = V_0 + at$

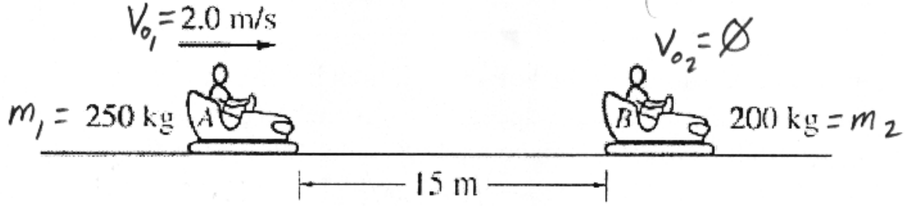
$V_0 = 2\,m/s$ $\quad t = \frac{V - V_0}{a} = 2\,s$

$\Delta x = V_0 t + \frac{1}{2}at^2 = 7\,m$

(then) $\bar{V} = 5\,m/s$

$\Delta x = 8\,m$ left

$t = \frac{\Delta x}{\bar{V}} = 1.6\,s$



2008 1. (10 points)
Several students are riding in bumper cars at an amusement park. The combined mass of car *A* and its occupants is 250 kg. The combined mass of car *B* and its occupants is 200 kg. Car *A* is 15 m away from car *B* and moving to the right at 2.0 m/s, as shown, when the driver decides to bump into car *B*, which is at rest.

(a) Car *A* accelerates at 1.5 m/s^2 to a speed of 5.0 m/s and then continues at constant velocity until it strikes car *B*. Calculate the total time for car *A* to ~~travel the~~ 15 m.

total time $\quad 7 + 1.6 = \boxed{8.6\,s}$

(b) After the collision, car *B* moves to the right at a speed of 4.8 m/s.

i. Calculate the speed of car *A* after the collision.

$V_2 = 4.8\,m/s$ $\quad$ COM $\quad m_1 V_{1_0} = m_1 V_1 + m_2 V_2$

$V_1 = \frac{m_1 V_{1_0} - m_2 V_2}{m_1}$

$\boxed{V_1 = 1.16\,m/s}$

ii. Indicate the direction of motion of car *A* after the collision.

____ To the left _✓_ To the right ____ None; car *A* is at rest.

(c) Is this an elastic collision?

____ Yes _✓_ No

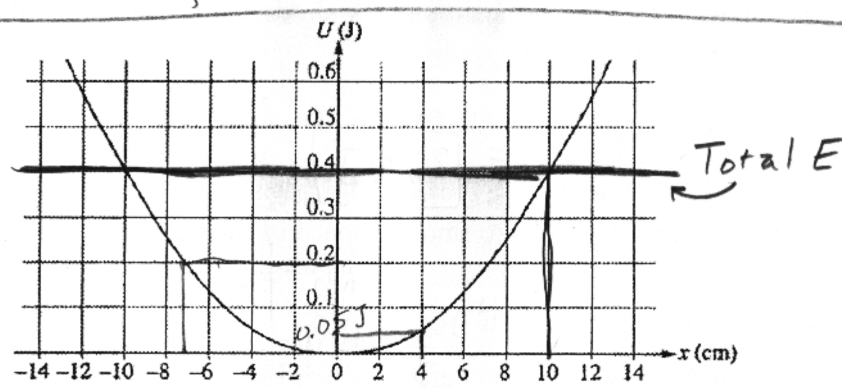
Justify your answer.

Check the kinetic Energy

$K_0 = \frac{1}{2} m_1 v_{1_0}^2 = 3125\,J$

$K_f = \frac{1}{2} m_1 v_1^2 + \frac{1}{2} m_2 v_2^2 = 2472\,J$

Not the same



2002B2 (15 points) A 3.0 kg object subject to a restoring force *F* is undergoing simple harmonic motion with a small amplitude. The potential energy *U* of the object as a function of distance x from its equilibrium position is shown above. This particular object has a total energy *E*: of 0.4 J.

(a) What is the object's potential energy when its displacement is +4 cm from its equilibrium position?

see graph $U = 0.05\,J$

(b) What is the farthest the object moves along the x-axis in the positive direction? Explain your reasoning.

10cm, the total Energy only allows this distance. (0.4J)

(c) Determine the object's kinetic energy when its displacement is -7 cm.

$U = 0.2\,J$ so $E = K + U$

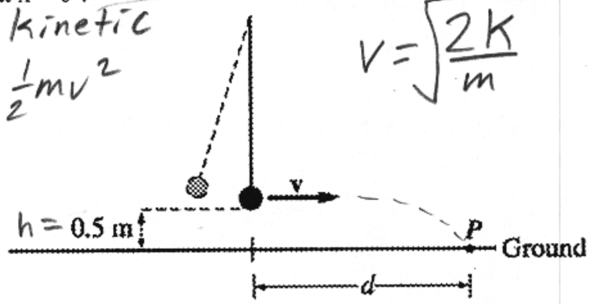
$K = E - U = 0.4 - 0.2 = \boxed{0.2\,J}$

(d) What is the object's speed at x = 0 ?

All energy is kinetic

$K = 0.4\,J$ $K = \frac{1}{2}mv^2$

$v = \sqrt{\frac{2K}{m}} = \sqrt{\frac{2(0.2)}{3}} = \boxed{0.37\,m/s}$

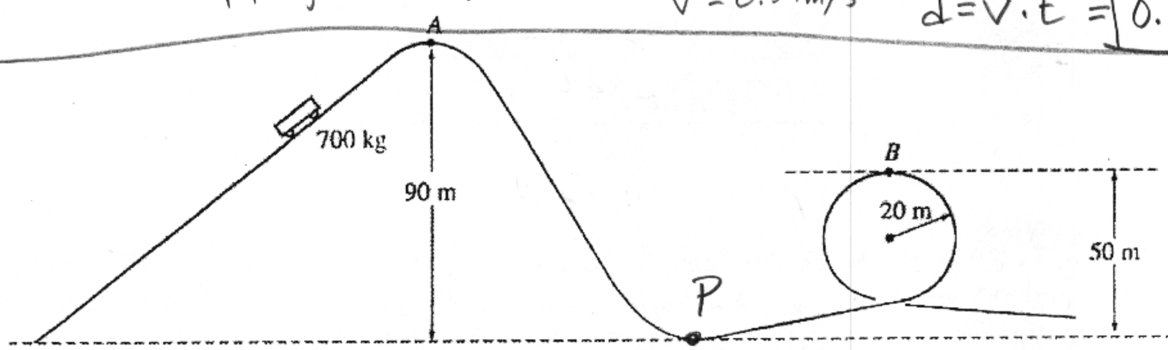


Note: Figure not drawn to scale.

(e) Suppose the object undergoes this motion because it is the bob of a simple pendulum as shown above. If the object breaks loose from the string at the instant the pendulum reaches its lowest point and hits the ground at point P shown, what is the horizontal distance d that it travels? $\Delta x = v \cdot t$

Projectile! $t = \sqrt{\frac{2h}{g}} = 0.32\,s$

$v = 0.37\,m/s$ $d = v \cdot t = \boxed{0.12\,m}$



2004B1. (15 points) A roller coaster ride at an amusement park lifts a car of mass 700 kg to point A at a height of 90 m above the lowest point on the track, as shown above. The car starts from rest at point A, rolls with negligible friction down the incline and follows the track around a loop of radius 20 m. Point B, the highest point on the loop, is at a height of 50 m above the lowest point on the track.

(a)

i. Indicate on the figure the point P at which the maximum speed of the car is attained.

ii. Calculate the value v_{max} of this maximum speed.

COE

$K_0 + U_0 = K + \cancel{U}$

$\cancel{m}gh = \frac{1}{2}\cancel{m}v^2$

$v = \sqrt{2gh} = \sqrt{2(10)(90)} = \boxed{42.4\,m/s}$

(b) Calculate the speed v_B of the car at point *B*. $h_2 = 50m$ $h_1 = 90m$

$U_0 + \cancel{K_0} = U + K$

$\cancel{m}gh_1 = \cancel{m}gh_2 + \frac{1}{2}\cancel{m}v^2$ $V = \sqrt{2(gh_1 - gh_2)} = \boxed{28.3 m/s}$

(c)

i. On the figure of the car below, draw and label vectors to represent the forces acting on the car when it is upside down at point *B*.

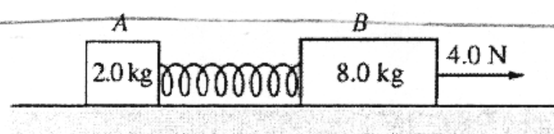
ii. Calculate the magnitude of all the forces identified in (c)i.

$mg = 7000 N$ $\Sigma F_c = m a_c$ $N + mg = \frac{mv^2}{r}$

$N = \frac{mv^2}{r} - mg = \boxed{21,031 N}$

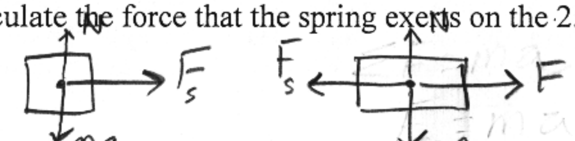
(d) Now suppose that friction is not negligible. How could the loop be modified to maintain the same speed at the top of the loop as found in (b)? Justify your answer.

lower the loop so more of the energy will be kinetic.



2008 2. (15 points)
Block *A* of mass 2.0 kg and block *B* of mass 8.0 kg are connected as shown above by a spring of spring constant 80 N/m and negligible mass. The system is being pulled to the right across a horizontal frictionless surface by a horizontal force of 4.0 N, as shown, with both blocks experiencing equal constant acceleration.

(a) Calculate the force that the spring exerts on the 2.0 kg block. $F_s = (2)(0.4) = \boxed{0.8N}$



$\Sigma F = m_1 a$ $\Sigma F = m_2 a$

$F_s = m_1 a$ $F - F_s = m_2 a$

$\cancel{F_s} + F - \cancel{F_s} = (m_1 + m_2) a$

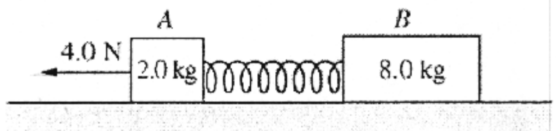
(b) Calculate the extension of the spring.

$|F| = kx$ $x = \frac{F_s}{k} = \boxed{0.01m}$

The system is now pulled to the left, as shown below, with both blocks again experiencing equal constant acceleration.

$a = \frac{F}{m_1 + m_2}$

$a = 0.4 m/s^2$



(c) Is the magnitude of the acceleration greater than, less than, or the same as before?

____ Greater ____ Less _✓_ The same

Justify your answer.

Same ΣF same mass

(d) Is the amount the spring has stretched greater than, less than, or the same as before?

_✓_ Greater ____ Less ____ The same

Justify your answer.

$F_s = m_2 a = (8)(0.4) = \boxed{3.2N}$

F_s is now greater has to pull larger mass

(e) In a new situation, the blocks and spring are moving together at a constant speed of 0.50 m/s to the left. Block *A* then hits and sticks to a wall. Calculate the maximum compression of the spring.

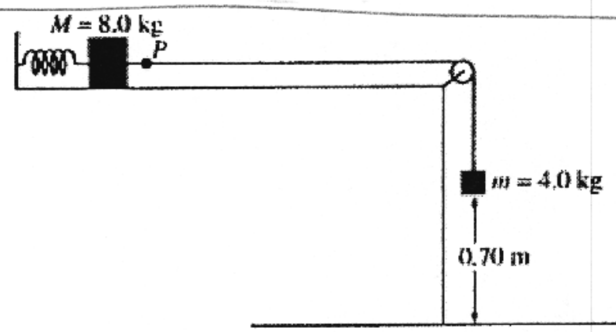
COE

$K_0 + \cancel{U_0} = \cancel{K} + U_s$

$\cancel{\tfrac{1}{2}}mv^2 = \cancel{\tfrac{1}{2}}kx^2$

$V = 0.5 m/s$

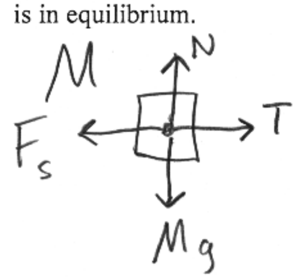
$X = \sqrt{\frac{mv^2}{k}} = \sqrt{\frac{8(0.5)^2}{80}} = \boxed{0.16 m}$

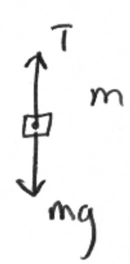


2006 B1 (15 points)

An ideal spring of unstretched length 0.20 m is placed horizontally on a frictionless table as shown above. One end of the spring is fixed and the other end is attached to a block of mass *M* = 8.0 kg. The 8.0 kg block is also attached to a massless string that passes over a small frictionless pulley. A block of mass *m* = 4.0 kg hangs from the other end of the string. When this spring-and-blocks system is in equilibrium, the length of the spring is 0.25 m and the 4.0 kg block is 0.70 m above the floor.

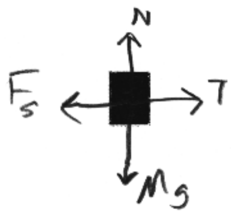
(a) On the figures below, draw free-body diagrams showing and labeling the forces on each block when the system is in equilibrium.





$a = \emptyset$

$M = 8.0$ kg



$\Sigma F = Ma$

$T - F_s = \emptyset$

$m = 4.0$ kg

$\Sigma F = ma$

$mg - T = \emptyset$

$T = mg$

(b) Calculate the tension in the string.

$T = mg = \boxed{40N}$

(c) Calculate the force constant of the spring.

$T = F_s = \boxed{40N}$

The string is now cut at point *P*.

(d) Calculate the time taken by the 4.0 kg block to hit the floor.

$h = 0.7m$

$V_o = \emptyset$

$\Delta y = \cancel{V_{oy}t} - \frac{1}{2}gt^2$

$h = \frac{1}{2}gt^2$

$t = \sqrt{\frac{2h}{g}} = \boxed{0.37_s}$

(e) Calculate the maximum speed attained by the 8.0 kg block.

X at equilibrium = 0.2m

X stretched = 0.25m

$|F_s| = kx$

$k = \frac{F_s}{x} = \frac{40N}{0.05_m} = 800 N/m$

$X = 0.05_m$

COE

$\cancel{K_o} + U_o = K + \cancel{U}$

$\cancel{\frac{1}{2}}kx^2 = \cancel{\frac{1}{2}}mv^2$

$v = \sqrt{\frac{kx^2}{m}} = \sqrt{\frac{(800)(0.05)^2}{8}} = \boxed{0.5 m/s}$