**Problem Set 1 (Due 3/11/2025 before class)**

**Late homework will NOT be accepted, unless you have notified the course instructor 3 days BEFORE deadline.**

**Part I (60%)**

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**REPONSE:**

**Given:**

* **Initial speed of the car and truck**: v0=20.0 m/s*v*0​=20.0m/s
* **Initial distance between the car's front bumper and the truck's rear bumper**: 24.0 m24.0m
* **Acceleration of the car**: a=0.600 m/s2*a*=0.600m/s2
* **Final position requirement**: The rear of the car is 26.0 m26.0m ahead of the front of the truck.
* **Length of the car**: 4.5 m4.5m
* **Length of the truck**: 21.0 m21.0m

**(a) Time Required for the Car to Pass the Truck**

1. **Total distance the car needs to cover relative to the truck**:
   * The car needs to cover the initial gap of 24.0 m24.0m.
   * It needs to move ahead by 26.0 m26.0m.
   * It also needs to account for the lengths of the car and the truck: 4.5 m+21.0 m=25.5 m4.5m+21.0m=25.5m.
   * **Total relative distance**: 24.0 m+26.0 m+25.5 m=75.5 m24.0m+26.0m+25.5m=75.5m.
2. **Relative acceleration**:
   * The truck is moving at a constant speed, so its acceleration is 0 m/s20m/s2.
   * The car's acceleration is 0.600 m/s20.600m/s2.
3. **Using the equation of motion**:

d=v0t+12at2*d*=*v*0​*t*+21​*at*2

Here, d=75.5 m*d*=75.5m, v0=0 m/s*v*0​=0m/s (relative to the truck), and a=0.600 m/s2*a*=0.600m/s2.

75.5=0⋅t+12⋅0.600⋅t275.5=0⋅*t*+21​⋅0.600⋅*t*275.5=0.300t275.5=0.300*t*2t2=75.50.300=251.67*t*2=0.30075.5​=251.67t=251.67≈15.86 s*t*=251.67​≈15.86s

**(b) Distance the Car Travels During This Time**

Using the equation of motion:

d=v0t+12at2*d*=*v*0​*t*+21​*at*2

Here, v0=20.0 m/s*v*0​=20.0m/s, a=0.600 m/s2*a*=0.600m/s2, and t=15.86 s*t*=15.86s.

d=20.0⋅15.86+12⋅0.600⋅(15.86)2*d*=20.0⋅15.86+21​⋅0.600⋅(15.86)2d=317.2+0.300⋅251.67*d*=317.2+0.300⋅251.67d=317.2+75.5=392.7 m*d*=317.2+75.5=392.7m

**(c) Final Speed of the Car**

Using the equation:

v=v0+at*v*=*v*0​+*at*

Here, v0=20.0 m/s*v*0​=20.0m/s, a=0.600 m/s2*a*=0.600m/s2, and t=15.86 s*t*=15.86s.

v=20.0+0.600⋅15.86*v*=20.0+0.600⋅15.86v=20.0+9.516=29.516 m/s*v*=20.0+9.516=29.516m/s

**Summary:**

* **(a) Time required**: ≈15.86 s≈15.86s
* **(b) Distance traveled by the car**: ≈392.7 m≈392.7m
* **(c) Final speed of the car**: ≈29.52 m/s≈29.52m/s

A math problem with numbers and equations

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**RESPONSE:**

**Given:**

* **Car A's position function**:

xA(t)=αt+βt2*xA*​(*t*)=*αt*+*βt*2

with α=2.60 m/s*α*=2.60m/s and β=1.20 m/s2*β*=1.20m/s2.

* **Car B's position function**:

xB(t)=γt2−δt3*xB*​(*t*)=*γt*2−*δt*3

with γ=2.80 m/s2*γ*=2.80m/s2 and δ=0.20 m/s3*δ*=0.20m/s3.

**(a) Which car is ahead just after they leave the starting point?**

To determine which car is ahead just after they leave the starting point, we evaluate the position functions at t=0*t*=0.

* **Car A**:

xA(0)=α⋅0+β⋅02=0*xA*​(0)=*α*⋅0+*β*⋅02=0

* **Car B**:

xB(0)=γ⋅02−δ⋅03=0*xB*​(0)=*γ*⋅02−*δ*⋅03=0

Both cars are at the starting point at t=0*t*=0. To see which car is ahead just after t=0*t*=0, we can look at their velocities.

* **Velocity of Car A**:

vA(t)=dxAdt=α+2βt*vA*​(*t*)=*dtdxA*​​=*α*+2*βt*

At t=0*t*=0:

vA(0)=2.60 m/s*vA*​(0)=2.60m/s

* **Velocity of Car B**:

vB(t)=dxBdt=2γt−3δt2*vB*​(*t*)=*dtdxB*​​=2*γt*−3*δt*2

At t=0*t*=0:

vB(0)=0 m/s*vB*​(0)=0m/s

Since vA(0)>vB(0)*vA*​(0)>*vB*​(0), **Car A** is ahead just after they leave the starting point.

**(b) At what time(s) are the cars at the same point?**

To find when the cars are at the same point, set xA(t)=xB(t)*xA*​(*t*)=*xB*​(*t*):

αt+βt2=γt2−δt3*αt*+*βt*2=*γt*2−*δt*3

Rearrange:

δt3+(β−γ)t2+αt=0*δt*3+(*β*−*γ*)*t*2+*αt*=0

Substitute the given values:

0.20t3+(1.20−2.80)t2+2.60t=00.20*t*3+(1.20−2.80)*t*2+2.60*t*=0

Simplify:

0.20t3−1.60t2+2.60t=00.20*t*3−1.60*t*2+2.60*t*=0

Factor out t*t*:

t(0.20t2−1.60t+2.60)=0*t*(0.20*t*2−1.60*t*+2.60)=0

This gives one solution at t=0*t*=0. To find other solutions, solve the quadratic equation:

0.20t2−1.60t+2.60=00.20*t*2−1.60*t*+2.60=0

Divide by 0.20:

t2−8t+13=0*t*2−8*t*+13=0

Using the quadratic formula:

t=8±64−522=8±122=4±3*t*=28±64−52​​=28±12​​=4±3​

So, the times are:

t=0, 4−3≈1.27 s, 4+3≈6.73 s*t*=0,4−3​≈1.27s,4+3​≈6.73s

**(c) At what time(s) is the distance from A*A* to B*B* neither increasing nor decreasing?**

The distance between the cars is neither increasing nor decreasing when their velocities are equal. Set vA(t)=vB(t)*vA*​(*t*)=*vB*​(*t*):

α+2βt=2γt−3δt2*α*+2*βt*=2*γt*−3*δt*2

Rearrange:

3δt2+(2β−2γ)t+α=03*δt*2+(2*β*−2*γ*)*t*+*α*=0

Substitute the given values:

3⋅0.20t2+(2⋅1.20−2⋅2.80)t+2.60=03⋅0.20*t*2+(2⋅1.20−2⋅2.80)*t*+2.60=0

Simplify:

0.60t2−3.20t+2.60=00.60*t*2−3.20*t*+2.60=0

Divide by 0.20:

3t2−16t+13=03*t*2−16*t*+13=0

Using the quadratic formula:

t=16±256−1566=16±1006=16±106*t*=616±256−156​​=616±100​​=616±10​

So, the times are:

t=266≈4.33 s, 66=1 s*t*=626​≈4.33s,66​=1s

**(d) At what time(s) do A*A* and B*B* have the same acceleration?**

To find when the accelerations are equal, set aA(t)=aB(t)*aA*​(*t*)=*aB*​(*t*):

* **Acceleration of Car A**:

aA(t)=dvAdt=2β=2⋅1.20=2.40 m/s2*aA*​(*t*)=*dtdvA*​​=2*β*=2⋅1.20=2.40m/s2

* **Acceleration of Car B**:

aB(t)=dvBdt=2γ−6δt*aB*​(*t*)=*dtdvB*​​=2*γ*−6*δt*

Set aA(t)=aB(t)*aA*​(*t*)=*aB*​(*t*):

2.40=2⋅2.80−6⋅0.20t2.40=2⋅2.80−6⋅0.20*t*

Simplify:

2.40=5.60−1.20t2.40=5.60−1.20*t*

Solve for t*t*:

1.20t=5.60−2.40=3.201.20*t*=5.60−2.40=3.20t=3.201.20≈2.67 s*t*=1.203.20​≈2.67s

**Part II (40%) Basic Problems**

1. How fast will an object (in motion along the x-axis) be moving at t = 10 s if it had a speed of 2 m/s at t = 0 and a constant acceleration of 2 m/s?
2. A car accelerates from rest at 4 m/s2. What is the velocity of the car after 4 seconds?
3. Consider the position vs. time graph for a moving object, as shown in the figure below. At which numbered points does the object have the greatest speed?

A graph of a function

AI-generated content may be incorrect.A graph of a function

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1. See figure below (lower left) a car is moving at a constant rate along the 2 axis. Which of the following velocity vs. time graphs (lower right) describes the motion of the car? Take **right** as **positive** direction.

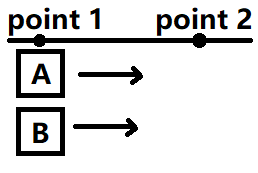
A car with a red arrow pointing to the side

AI-generated content may be incorrect. A diagram of a graph

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1. A car is rolling toward a cliff with an initial speed of 15 m/s. The maximum negative acceleration that the brakes can provide is -0.3 m/s. If the cliff is 350 m from the initial position of the car, will the car go over the cliff?
2. Cart A moves with a uniform speed past point 1 on a straight track at 0.3 m/s. At the same time, Cart B moves past point 1 at 0.1 m/s but is uniformly accelerating at 0.1 m/s. Point 2 is 1.0 m past point 1. Which cart gets to point 2 first?

Scheme:



1. A small ball is released from a window at t = 0. Assuming free-fall conditions, how far does it travel in 2.8 seconds? If the ball had more mass would it fall a greater distance?
2. A car moving at 20 m/s passes a street corner. The car maintains this speed even though the speed limit is 10 m/s. The police car that was sitting at the corner begins to chase the car by accelerating at 2 m/s. How long will it take for the police car to catch the speeder? How far from the corner is the catch-up point? How fast will the police car be traveling at that time?
3. Determine the distance between two steel spheres (after 1.4 s) dropped from a tower if the second sphere was dropped 0.5 seconds after the first. Assume free-fall and that the spheres are dropped from rest.
4. A car accelerates uniformly from rest to a velocity of 101 km/h east in 8.0 s. What is the magnitude of its acceleration?