Fundamentals of Mechanics - CIVE 1140

Kinetics Examples

Section 1: Velocity and acceleration

1.1 A swimmer swims at a steady 1m/s across a lake and then swims back at a steady speed of 0.5m/s. What is the swimmers average speed?
(2/3 m/s)

1.2 A car travelling at 50 km/h stops in 11m. Find its deceleration (assuming it is uniform.)
(8.87 m/s^2)

1.3 A wagon starts to run, from rest, down an incline. In 30 s it travels 100m. How long would it take to travel 800m from rest?
(8.48 s)

1.4 A stone is dropped down a vertical shaft 200m deep. The speed of sound in air is 330 m/s. Find the time that elapses before the person dropping the stone hears it hit the bottom.
(6.986 s)

1.5 A lift starts from rest and accelerates at 2m/s^2 until it reaches a speed of 3m/s. It then travels at constant speed until it is finally brought to rest with a deceleration of 1m/s^2. The total time of motion is 20s. Sketch the speed / time graph and find the total distance travelled.
(53.25 m)

1.6 A crane lifts a load of 900kg vertically with constant acceleration from rest. The load rises 10m in 5s. Find the acceleration of the load and the tension in the lifting cable.
(0.8 m/s^2, 9.54 kN)

1.7 A hoist raises material from the ground to the top of a building 100m high. It accelerates at 1m/s^2 for 1s and decelerates at 0.8m/s^2. Sketch the speed / time graph and find the uniform speed and the total time of travel from the ground to the top of the building.
(1 m/s, 101.125 s)

1.8 A train accelerates and decelerates at 0.5m/s^2. What is the minimum time it can take to travel between two stations 5km apart?
(200 s)

1.9 A man gets out of a train and walks along the platform at 2m/s. the train begins to move 30s later and accelerates at 0.5m/s^2. How much further time will elapse before the door from which the man left the train overtakes him?
(20 s)

1.10 A pulley with diameter 1m rotates 120 times per minute. It has a belt passing round it. What is the angular speed of the pulley? What is the linear speed of the belt?
(12.57 rad/s, 6.28 m/s)

1.11 Find the linear speed of a point on the earth's equator assuming that the radius of the earth is 6380km
(464 m/s)

1.12 A flywheel rotates at 300 rev/min. It slows down uniformly to 180 rev/min in 30s. What is its angular acceleration?
(-0.42 rad/s^2)

1.13 A grinding wheel is accelerated uniformly from rest to 3000 rev/min in 3.0s. Find its angular acceleration. If the wheel diameter is 200mm, find the final linear speed of a point on its rim.
(104 rad/s^2, 31.4 m/s)

1.14 A train on a level straight track accelerates uniformly from rest to 60 km/h in a distance of 300m. Find its acceleration. If the driving wheels are 1.5m diameter, find their angular acceleration and the final angular speed of a point on the rim of the wheel.
(0.463 m/s^2, 0.617 rad/s^2, 22.2 rad/s)

Section 2: Mass, Force and Acceleration

2.1 A resultant force of 100N on a body produces an acceleration of 0.1m/s^2. Find the weight of the body.
(9.81 kN)

2.2 What force is required to accelerate a car of mass 2000 kg from rest to 50 km/h in 10s?
(2778 N)

2.3 The engine of a train of total mass 200 tonnes exerts a pull of 70 kN and resistance to motion is 15 kN. Find the acceleration of the train.
(0.2 ^{2})

2.4 Find the time taken for a barge of mass 10 000 kg moving at 1.5 m/s to be brought to rest if the only force on it is due to a rope in which the tension is 10 kN. Find also the distance gone in this time.
(1.5 s, 1.125 m)

2.5 A man of mass 70 kg stands in a lift. What will be the force exerted on him by the floor of the lift when a) the lift is at rest, b) the lift is ascending with an acceleration of 1 m/s^2 c) the lift is descending with an acceleration of 1 m/s^2 and d) the lift is moving upwards with uniform speed of 2 m/s.
(686.7 N, 756.7 N, 616.7 N, 686.7 N)

2.6 A train of mass 200 tonnes travels with uniform speed along a straight level track. The total resistance to motion is 50 N/tonne. What is the driving force at the wheels of the engine?
(10 kN)

2.7 If the train in the question above now accelerates at 0.2 m/s^2, what is the new value of the driving force? (Take the resistance to motion to be the same as above.)
(50 kN)

2.8 An electric train has total mass of 300 tonnes and the tractive force is 100 kN. If the frictional force is 25 kN and constant, find the acceleration a) along the level, b) up an incline of 1 in 150 (along the incline) c) down an incline of 1 in 100 (along the incline.)
(0.25 m/s^2, 0.185 m/s^2, 0.348 m/s^2)

2.9 A 2 tonne truck is pulled at uniform speed up an incline of 1 in 10 along the slope by a rope parallel to the incline. The rope passes over a frictionless pulley at the top of the incline and has a mass of 275 kg hanging freely at its end. Find the resistance to motion parallel to the incline.
(736 N)

2.10 A hoist of mass 12 tonnes is pulled vertically upwards form rest by a cable, first with uniform acceleration 1 m/s^2 then at uniform speed and finally with uniform deceleration 2 m/s^2. Find the tension in the cable in the three parts of the motion.
(129720 N, 117720 N, 93720 N)

2.11 The normal reaction between the driving wheels of a train and the track is 1000kN and the coefficient of friction is 0.25. What is the greatest force that can be exerted by the train parallel to the track? Find the maximum acceleration when the train is pulling wagons of total mass 200 tonnes and the total resistance to motion is 50 kN.
(250 kN, 0.662 m/s^2)

2.12 Masses of 5kg and 4 kg are attached to the ends of a light string passing over a light frictionless pulley. Find the acceleration of the masses and the tension in the string.
(1.09 m/s^2, 43.6 N)

2.13 A thin flexible wire passes over a pulley. Masses of 2.6 kg and 2.0 kg are attached at each end of the wire. The system is released from rest when the two masses are at the same horizontal level. Ignoring friction, find the acceleration of the masses, the tension in the wire and the time taken for the two masses to be 0.5m vertical apart.
(1.28 m/s^2, 22.2 N, 0.625 s)

2.14 A car travels at a constant speed of 60 km/h round a circular track with radius 100m banked at an angle θ, to the horizontal. Find the value of θ if there is to be no lateral frictional force between the tyres and the track.
(15.8 degrees)

2.15 An astronaut undergoing training is bjected to high acceleration forces by putting him in a cabin moving in a horizontal circle at the end of a whirling arm of effective length 8m. Find the speed of rotation of the arm which would give him an acceleration of $10g$.
(33.4 rev/min)

Section 3: Work, Power and Energy

3.1 Find the work done in raising a lift of people through 20 m if the total mass is 2000kg.
(392 400 J)

3.2 What amount of work is require to pull a 30kg load a distance of 10 m up a smooth incline of 1 in 10 (along the slope)?
(294 J)

3.3 The force on a body varies with distance as shown in this table:

Force (kN)	0	7	14	25	31	28	17
Distance moved(m)	0	10	20	40	50	80	100

Find the work done as the body moves 100m
(2090 kJ)

3.4 The force exerted on a truck varies with distance moved as shown in the table:

Force (kN)	5.0	3.8	2.3	1.6	1.4	1.8	1.7	1.0	0
Distance (m)	0	10	20	30	40	50	60	70	80

Find the total work done during the 80m.
(161 kJ)

3.5 What is the potential energy of a 20 kg mass (relative to the earth's surface) when it is a)50m above the surface of the earth b) down a mineshaft 500m deep.
(9.81 kJ, -98.1kJ)

3.6 A lift of mass 1000 kg moves from the second floor of a building 8m above ground level to the sixth floor 24 m above ground level. What change in potential energy has there been?
(156960 J)

3.7 What is the kinetic energy of a mass of 0.08 kg travelling at 16 m/s?
(10.2 J)

3.8 Find the kinetic energy of a body if mass 2 kg when it falls under gravity a distance of 2m from rest.
(39.2 J)

3.9 A body of weight 20 N falls freely from rest, from a height of 10m above ground. Find the potential energy, the kinetic energy and the sum of the potential and kinetic energies: a) just before he body is released; b) when it has fallen 2m; c) just as it hits the ground.
(200 J, 0, 200 J, 160 J, 40 J, 200 J, 0, 200 J, 200 J)

3.10 A man of mass 70 kg runs up a flight of 50 steps each 0.25 m high in 25 s. What is his rate of working?
(343.35 W)

3.11 A car engine has an output of 8 kW. Find the resistance to motion when the car travels at a steady speed of 15 m/s along a level road.
(533 N)

3.12 A 2kg body is projected up a rough slope at 30° to the horizontal with an initial kinetic energy of 200 J. The coefficient of friction is 0.2. Find: a) the retarding force; b) the retardation; c) the distance gone before coming to rest; d) the gain in potential energy, and hence e) the loss in energy due to friction
(13.2N, 6.6m/s^2, 15.2m, 149 J, 51 J)

3.13 An electric water pump with overall efficiency 55% raises 100 000kg of water per hour through 30m and delivers it at a speed of 1m/s. Find the kinetic energy supplied to the water per second and the power expended in pumping the water. Also find the power input to the pump.
(13.9 J, 8.175 kJ, 14.9 kW)

3.14 The engine of a car has a maximum power output of 50 kW and the car's transmission has an efficiency of 70%. If the mass of the car is 1 tonne and the total resistance to motion is a constant 600 N, find the maximum speed which the car can achieve a) along a horizontal track b) going up a track 1 in 50 (along the incline).(58.3 m/s, 44.0m/s)

3.15 An engine with power 150 kW pulls a train with total mass 150 000 kg up an incline of 1 in 250 (along the slope). The resistance to motion is a constant 20N per 1000 kg. Find a) the total force down the incline, b) the maximum uniform speed.
(8.89 kN, 16.9 m/s)

3.16 A mine shaft 200 m deep, of cross-sectional area 12 m^2, has water in it 70m deep. The water is pumped out to ground level in 6 hours and delivered at 5m/s. Find a) the potential energy given to the water; b) the kinetic energy given to the water c) the average power of the pump. (Density of water is 1000kg/m^3)
(1.360 MJ, 10.5 MJ, 63.4 kW)

3.17 A turbine is driven by a waterfall where 50m^3 of water per minute fall 10m vertically. A power of 40 kW is developed. What fraction of the available energy is used? (1m^3 of water has a mass of
(0.49)

3.18 A torque of 30Nm is applied to a shaft to turn it through 5 revolutions. What is the work done?
(942 J)

3.19 Find the torque at the shaft if an electric motor rated at 5 kW and with a speed of 1425 rev/min.
(33.5 Nm)

3.20 The torque required to operate a machine varies in the following way over two revolutions:
0 - 1/2 revolution, torque increases linearly from 0 to 800Nm
1/2 - 1 revolution, torque remains constant at 800 Nm
1 - 3/2 revolution, torque drops abruptly to 500 Nm and stant
3/2 - 2 revolution, torque decreases linearly to 0.
Find a) the work done during this 2 revolution cycle, b) the average value of the torque c) the power required by the machine if it operates at 240 rev/m.
(6.13 kJ, 487 Nm, 12.25 kW)