Q1.
A uniform horizontal beam of length 6.00 m and mass M = 100 kg is attached to the vertical wall by a rope making an angle θ = 60.0 º with the wall; the beam can rotate about the fixed pivot O as shown in Fig. 1. A mass m = 80.0 kg hangs from P at a distance 4.00 m from O. Find the tension in the rope attached to the wall.

A) 2.03×10^{3} N
B) 5.33×10^{2} N
C) 1.11×10^{3} N
D) 3.25×10^{3} N
E) 4.57×10^{3} N

Q2.
What increase in pressure is necessary to decrease the volume of a solid aluminum sphere by 0.050 % (Bulk Modulus of Aluminum = 7.00×10^{10} N/m^2)

A) 3.50×10^{7} Pa
B) 1.40×10^{5} Pa
C) 6.57×10^{7} Pa
D) 7.61×10^{7} Pa
E) 5.49×10^{7} Pa

Sec# Equilibrium and Elasticity - Elasticity
Grade# 50

Q3.
A certain wire stretches 0.90 cm when outward forces with magnitude F are applied to each of its ends. The same forces are applied to a second wire of the same material but with two times the diameter and three times the length. The second wire stretches:

A) 0.68 cm
B) 0.30 cm
C) 0.90 cm
D) 2.7 cm
E) 8.1 cm

Q4.
A non-uniform meter stick of mass 200 g is pivoted at the 0 cm mark and balances horizontally in a vertical plane. In addition to the reaction at the pivot and weight, two vertical forces are acting on it as shown in Fig. 2. Find the distance of the center of mass of the rod from the pivot.

A) 76 cm

B) 88 cm
C) 95 cm
D) 61 cm
E) 55 cm

Q5.
Each of the four corners of a square with side a is occupied by a point mass m. There is a fifth mass, also m, at the center of the square. To remove the mass from the center to a point very far away the work that must be done by an external agent is given by:

A) $+4\sqrt{2}Gm^2/a$
B) $-4Gm^2/a$
C) $+4Gm^2/a$
D) $-4\sqrt{2}Gm^2/a$
E) $+4Gm^2/a^2$

Sec# Gravitation - Gravitational Potential Energy
Grade# 45

Q6.
What is the mass of a planet, in units of Earth's mass M_E, whose radius is twice the radius of Earth and whose escape speed is twice that of the Earth?

A) 8 M_E
B) 4 M_E
C) 2 M_E
D) M_E /2
E) M_E /4

Q7.
A spherical shell has inner radius R_1, outer radius R_2, and mass M, distributed uniformly throughout the shell. The magnitude of the gravitational force exerted on the shell by a point particle of mass m, located a distance d from the center ($d < R_1$) is:

A) 0
B) GMm/R_2^2
C) GMm/d^2
D) GMm/R_1^2
E) $GMm / (R_1 - R_2)^2$

Q8.
A planet is in a circular orbit around the Sun. Its distance from the Sun is four times the average distance of Earth from the Sun. The period of this planet, in Earth years, is:

A) 8
B) 4
C) 2
D) 9
E) 6

Q9.
A penguin (bird) floats first in a fluid of density ρ_1 = 1.0 ρ, then in a fluid of density ρ_2 = 0.95 ρ, and then in a fluid of density ρ_3 = 1.1 ρ. **Rank the densities** of the fluids according to the amount of fluid displaced by the penguin, **GREATEST** first.

A) ρ_2, ρ_1, ρ_3
B) ρ_3, ρ_1, ρ_2
C) ρ_1, ρ_2, ρ_3
D) ρ_2, ρ_3, ρ_1
E) ρ_3, ρ_2, ρ_1

Q10.
A plastic sphere floats in water with 0.50 of its volume submerged. This same sphere floats in oil with 0.40 of its volume submerged. Determine the density of the oil.

A) 1.25×10^3 kg/m^3
B) 1.01×10^3 kg/m^3
C) 2.15×10^3 kg/m^3
D) 1.90×10^3 kg/m^3
E) 1.88×10^3 kg/m^3

Q11.
The open vertical tube in Fig. 3 contains three fluids of densities
ρ_1 = 300 kg/m^3, ρ_2 = 400 kg/m^3 and ρ_3 = 500 kg/m^3, which do not mix. Find the pressure at point B.

A) 1.03×10^5 Pa
B) 1.17×10^4 Pa
C) 5.34×10^6 Pa
D) 3.03×10^5 Pa
E) 1.51×10^5 Pa

Q12.
Fig. 4 shows an ideal fluid flowing in a horizontal tube. The pressure, velocity, and tube cross section area at point 1 and 2 are (P_1, v_1, A_1) and (P_2, v_2, A_2), respectively. If P_1=8.0 x 10^4 Pa, A_1=

$4A_2$, $P_2 = 6.0 \times 10^4$ Pa and $A_2 = 2.0 \times 10^{-3}$ m^2, at what volume rate does water flow through point 2? [Take density of water to be 1000 kg/m^3]

A) 0.013 m^3/s
B) 0.025 m^3/s
C) 0.037 m^3/s
D) 0.030 m^3/s
E) 0.050 m^3/s

Q13.
A vertical spring stretches 10 cm when a 5.0-kg block is suspended from its end. The block is then displaced an additional 5.0 cm downward and released from rest to execute Simple Harmonic Motion. The block position as a function of time is given by:
(Take equilibrium position of spring-block system as origin and the upward-vertical direction to be positive)

A) $y = -0.05 \cos(9.9\,t)$ m
B) $y = -0.15 \sin(9.9\,t)$ m
C) $y = -0.10 \cos(9.9\,t)$ m
D) $y = -0.10 \sin(9.9\,t + 9)$ m
E) $y = -0.15 \sin(9.9\,t + 5)$ m

Q14.
The motion of a particle attached to a spring is described by $x = 0.10 \sin(\pi t)$, where x is in meters and t in seconds. What is the earliest time at which the potential energy is equal to the kinetic energy?

A) 0.25 s
B) 0.53 s
C) 0.67 s
D) 0.79 s
E) 0.91 s

Q15.
A mass at the end of an ideal spring vibrates with period T. If an identical spring is attached to the end of the first spring and the same mass is hanging from the combination, the new period of oscillation is :

A) $\sqrt{2}\,T$
B) 2 T
C) T/ 4
D) T/ 2
E) $T/\sqrt{2}$

Q16.
The rotational inertia of a uniform thin rod about its end is $(ML^2)/3$, where M is the mass and L is the length. Such a rod is suspended vertically from one end and set into small angle oscillation. If L = 1.0 m this rod will have the same period as a simple pendulum of length:

A) 67 cm
B) 59 cm
C) 33 cm
D) 97 cm
E) 89 cm

Q17.
A motorist traveled a distance of 290 km. For the first half distance of 145 km he drove at a constant speed 48 km/h. At what constant speed he drove in the second half of distance if his average speed for the total distance was 64 km/h.

A) 96 km/h
B) 82 km/h
C) 72 km/h
D) 61 km/h
E) 55 km/h

Q18.
Two identical objects, A and B, fall from rest from different heights, H_A and H_B to the ground. If object B takes twice as long as A to reach the ground, what is the ratio of H_A to H_B (H_A/H_B)? Neglect air resistance.

A) 1/4
B) 1/8
C) 1/2
D) 1/3
E) 1/5

Q19.
If vector **B** is added to vector **C** = (30 **i** + 40 **j**) m, the resultant vector is directed along the positive x direction, with a magnitude equal to that of vector **C.** What is the magnitude of **B?**

A) 45 m
B) 75 m

C) 25 m
D) 71 m
E) 90 m

Q20.
A plane is heading east with an air speed of 800 km/h. (Air speed : plane's speed relative to air). If the wind is blowing to the south at 80 km/hr, find the velocity of the plane relative to the ground (Take East direction along **i** and South direction along **–j**).

A) (800**i** – 80.0**j**) km/h
B) (430**i** – 40.0**j**) km/h
C) (500**i** + 300**j**) km/h
D) (300**i** + 400**j**) km/h
E) (110**i** + 420**j**) km/h

Q21.
For a projectile motion, which one of the following statements is WRONG?

A) The velocity at the highest point is zero.
B) Potential energy is maximum at the highest point.
C) The acceleration is not zero at the highest point.
D) The kinetic energy does not remain constant.
E) The mechanical energy remains constant.

Q22.
A 70–kg man is riding an elevator that is moving up with a constant speed of 4.00 m/s. What is the force of the floor of the elevator on him?

A) 686 N
B) 771 N
C) 473 N
D) 241 N
E) 871 N

Q23.
An 80-kg passenger in a car presses against the car door with a 200N force when the car makes a turn at 20 m/s on the circular horizontal part of the road. Find the radius of the circular part of the road.

A) 160 m
B) 230 m
C) 310 m

D) 110 m
E) 190 m

Q24.
A 0.60-kg particle has a speed of 2.0 m/s at point A and kinetic energy of 7.5 J at point B. Find the total work done on the particle as it moves from A to B.

A) 6.3 J
B) 1.2 J
C) 7.5 J
D) 2.5 J
E) 4.3 J

Q25.
Consider a vertical spring with spring constant k. A 5-kg mass is released from rest at a height H= 60.0 cm above this spring. If the mass compresses the spring to a maximum distance h = 20.0 cm, as shown in Fig. 5, find the value of the spring constant k.

A) 1.96×10^3 N/m
B) 1.15×10^3 N/m
C) 7.35×10^3 N/m
D) 1.79×10^3 N/m
E) 5.00×10^3 N/m

Q26.
A rifle of mass M is initially at rest but free to recoil. It fires a bullet of mass m and velocity **v** (relative to the ground). After firing, the velocity of the rifle (relative to the ground) is:

A) −m**v**/M
B) −M**v**/m
C) −m**v**
D) −**v**
E) +m**v**/M

Q27.
A 5-kg object is in free fall. What is the magnitude of the change in its momentum in a one-second time interval?

A) 49 kg.m/s
B) 73 kg.m/s
C) 54 kg.m/s

D) 83 kg.m/s
E) 51 kg.m/s

Q28.
A disk starts from rest and rotates for 10 s around a fixed axis, subject to a constant net torque. The ratio of work done by the torque during the **first** 5 s interval and the **last** 5 s interval is:

A) 1/3
B) 3
C) 2
D) 1/2
E) 1/4

Q29.
A single force acts on a particle P, as shown in Fig. 6. Rank each of the orientations of the force shown below according to the magnitude of the time rate of change of the particle's angular momentum about the point O, **least to greatest**.

A) 1 and 2 tie, then 4, 3
B) 1 and 2 tie, then 3, 4
C) 1 , 2 , 3, 4
D) 1 and 2 tie, then 3 and 4 tie
E) All are the same

Q30.
A hoop rolls with constant velocity and without sliding along a level ground. Its rotational kinetic energy is:

A) the same as its translational kinetic energy
B) half its translational kinetic energy
C) twice its translational kinetic energy
D) four times its translational kinetic energy
E) one-third its translational kinetic energy

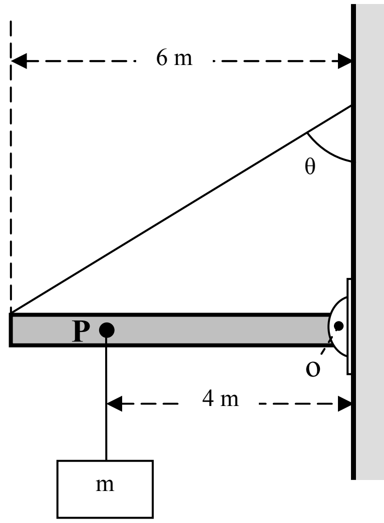

Fig 1

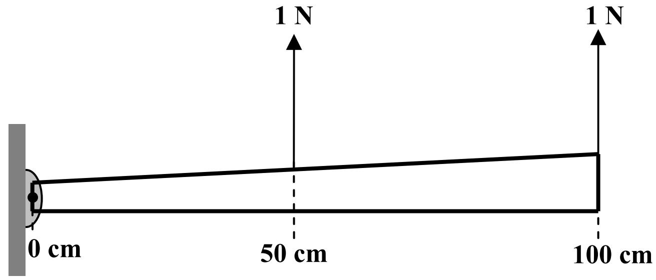

Fig 2

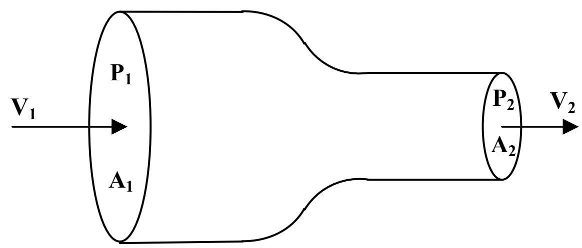

Fig 4

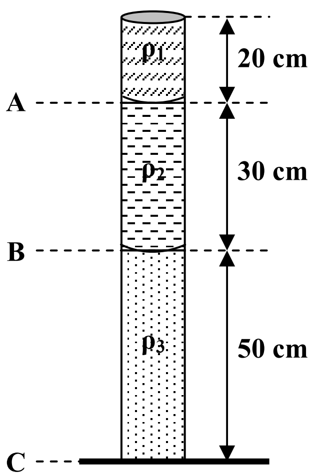

Fig 3

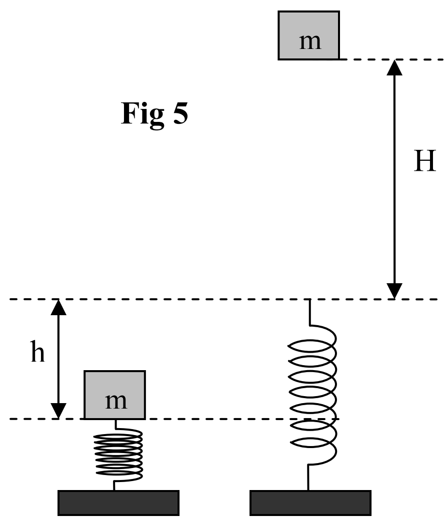

Fig 5

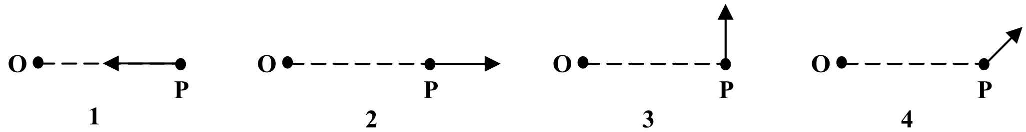

Fig 6

PHYSICS 101-082 FINAL EXAM FORMULA SHEET

$\vec{v} = \vec{v}_o + \vec{a}t$

$\vec{r} - \vec{r}_o = \vec{v}_o t + \frac{1}{2}\vec{a}t^2$

$v^2 = v_o^2 + 2\vec{a}\cdot(\vec{r} - \vec{r}_o)$

$\vec{r} - \vec{r}_o = \frac{1}{2}(\vec{v} + \vec{v}_o)t$

$a_r = \frac{v^2}{r}, a_t = \frac{d|\vec{v}|}{dt}, H = \frac{v_o^2 \sin^2\theta}{2g}, R = \frac{v_o^2}{g}\sin 2\theta_o$

$\vec{a} = \vec{a}_t + \vec{a}_r$

$\vec{F}_{net} = m\vec{a} = \frac{d\vec{p}}{dt}$

$f_k = \mu_k N$

$f_s \le \mu_s N$

$W = \int \vec{F}\cdot d\vec{s}$

If $\vec{F}$ is constant $W = \vec{F}\cdot\vec{s}$, $P = \vec{F}.\vec{v}$

$W_{net} = \Delta K = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$

$W_c = -\Delta U$

$\Delta U_s = \frac{1}{2}kx_f^2 - \frac{1}{2}kx_i^2, F_s = -kx$

$\Delta U_g = mg(y_f - y_i)$

$W = \Delta K + \Delta U + \Delta E_{th}; \quad \Delta E_{th} = f_k d$

$\vec{p} = m\vec{v}$

$\vec{J} = \Delta\vec{p} = \int \vec{F}dt = \vec{F}_{avg}\Delta t$

$\vec{p}_{1i} + \vec{p}_{2i} = \vec{p}_{1f} + \vec{p}_{2f}$

$\vec{R}_{cm} = \frac{\sum m_i\vec{r}_i}{\sum m_i} = \frac{1}{M}\int \vec{r}\,dm$

$\vec{v}_{cm} = \frac{\sum m_i\vec{v}_i}{\sum m_i}; \quad \vec{p}_{cm} = \sum m_i\vec{v}_i$

$\omega = \frac{d\theta}{dt}; \quad \alpha = \frac{d\omega}{dt}$

$s = r\theta, \ v = r\omega$

$a_t = r\alpha; \ a_r = r\omega^2$

If α is constant:

$\omega = \omega_o + \alpha t$

$\theta - \theta_o = \omega_o t + \frac{1}{2}\alpha t^2$

$\theta - \theta_0 = \frac{\omega + \omega_0}{2}t$

$\omega^2 = \omega_o^2 + 2\alpha(\theta - \theta_o)$

$I = \sum m_i r_i^2 = \int r^2\,dm$

$I_p = I_{com} + Md^2$

$\vec{\tau} = \vec{r}\times\vec{F} \qquad |\vec{A}\times\vec{B}| = AB\sin\theta$

$\vec{A}\cdot\vec{B} = A_xB_x + A_yB_y + A_zB_z, \ \vec{A}\cdot\vec{B} = AB\cos\theta$

$P = \frac{dW}{dt} = \tau\omega$

For a solid rotating about a fixed axis:

$K_{rot} = \frac{1}{2}I\omega^2; \quad L_z = I\omega$

$W = \int \tau\,d\theta$

$\vec{L} = \vec{r}\times\vec{p} = m(\vec{r}\times\vec{v})$

$\vec{\tau} = \frac{d\vec{L}}{dt}$

$\sum \tau_{ext} = \frac{dL}{dt} = I\alpha$

For static equilibrium

$\sum \vec{F} = 0, \quad \sum \vec{\tau} = 0$

$E = \frac{F/A}{\Delta L/L}; \ \mathrm{G} = \frac{F/A}{\Delta x/L}; \ \mathrm{B} = \frac{p}{|\Delta V|/V}$

$F = \frac{Gm_1m_2}{r^2}; \quad U = -\frac{Gm_1m_2}{r}; \ a_g = \frac{GM}{r^2}$

$E = \frac{1}{2}mv^2 - \frac{GMm}{r} = -\frac{GMm}{2r}$

$v_{esc} = \sqrt{\frac{2GM}{R}}; \qquad T^2 = \left(\frac{4\pi^2}{GM}\right)r^3$

$P = \frac{F}{A}; \quad \rho = \frac{m}{V}$

$P = P_o + \rho gh$

$F_b = m_f g$

$A_1v_1 = A_2v_2 = \text{constant}$

$P + \frac{1}{2}\rho v^2 + \rho gy = \text{constant}$

$x = x_m\cos(\omega t + \phi)$

$k = m\omega^2; \quad T = \frac{1}{f} = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{m}{k}}$

$E = K + U = \frac{1}{2}mv^2 + \frac{1}{2}kx^2 = \frac{1}{2}kx_m^2$

$T = 2\pi\sqrt{\frac{L}{g}}; \quad T = 2\pi\sqrt{\frac{I_p}{mgh}}$

$G = 6.67\times10^{-11}\,Nm^2/kg^2$

$P_{atm} = 1.01\times10^5\,Pa = 1\,atm \qquad 1Pa = 1N/m^2$

$I_{com}(cylinder) = \frac{1}{2}MR^2 = I_{com}(disk)$

$I_{com}(thin\ rod) = \frac{1}{12}ML^2$

$I_{com}(sphere) = \frac{2}{5}MR^2; \quad I_{com}(thin\ hoop) = MR^2$

$\rho_{water} = 1000\,kg/m^3; \quad g = 9.80\,m/s^2$

Earth $\left(M_E = 5.98\times10^{24}\,kg, R_E = 6.37\times10^6\,m\right)$