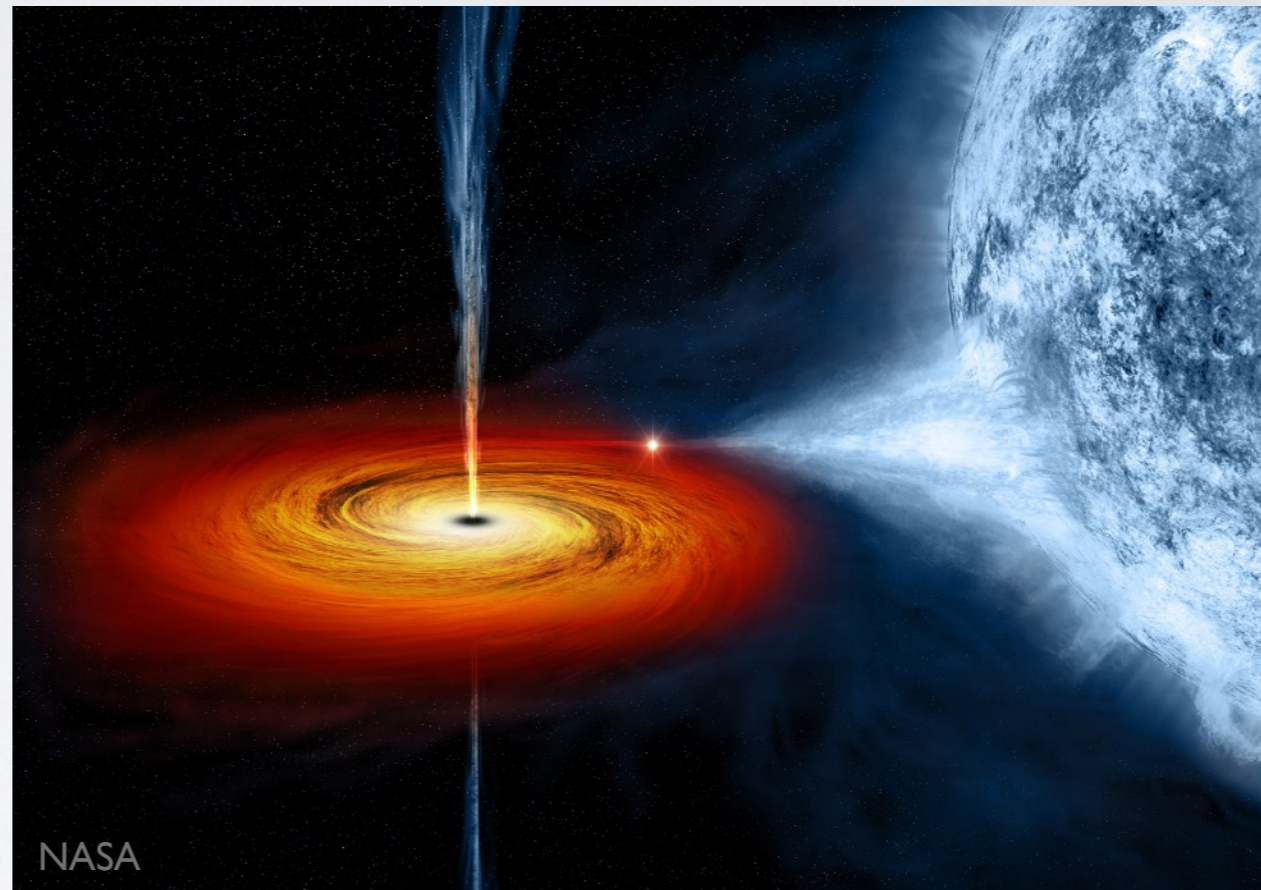
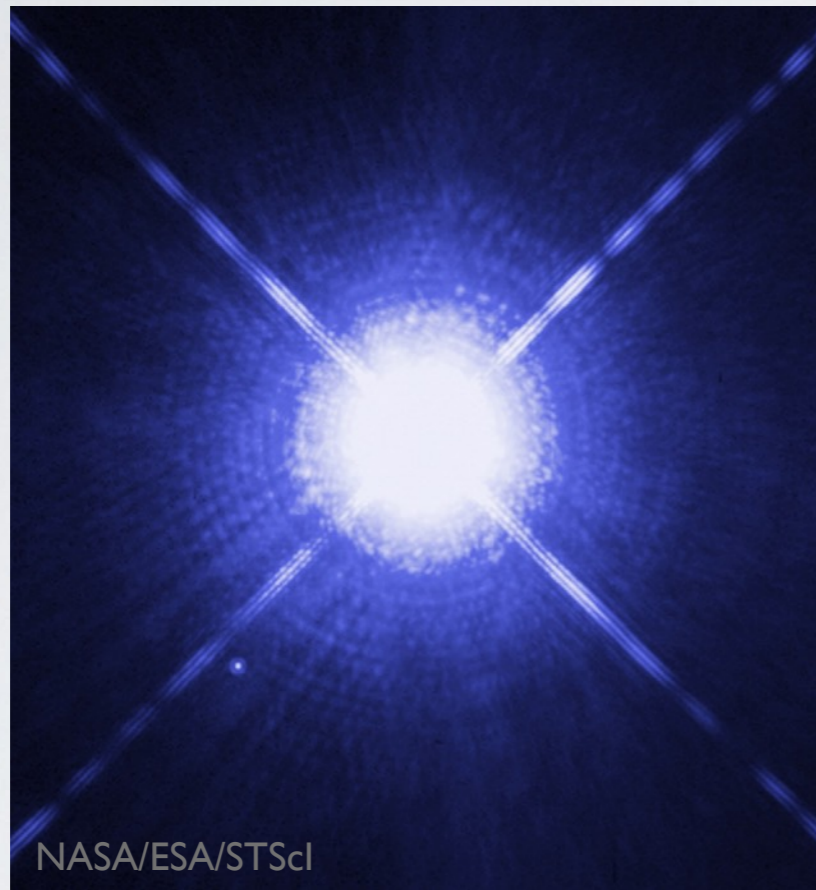


Week 12 - #1

Central Force Motion (I)



Today: Ch 7.10, 8.1-8.4

Next Class: Ch 8.5-8.7, 8.10

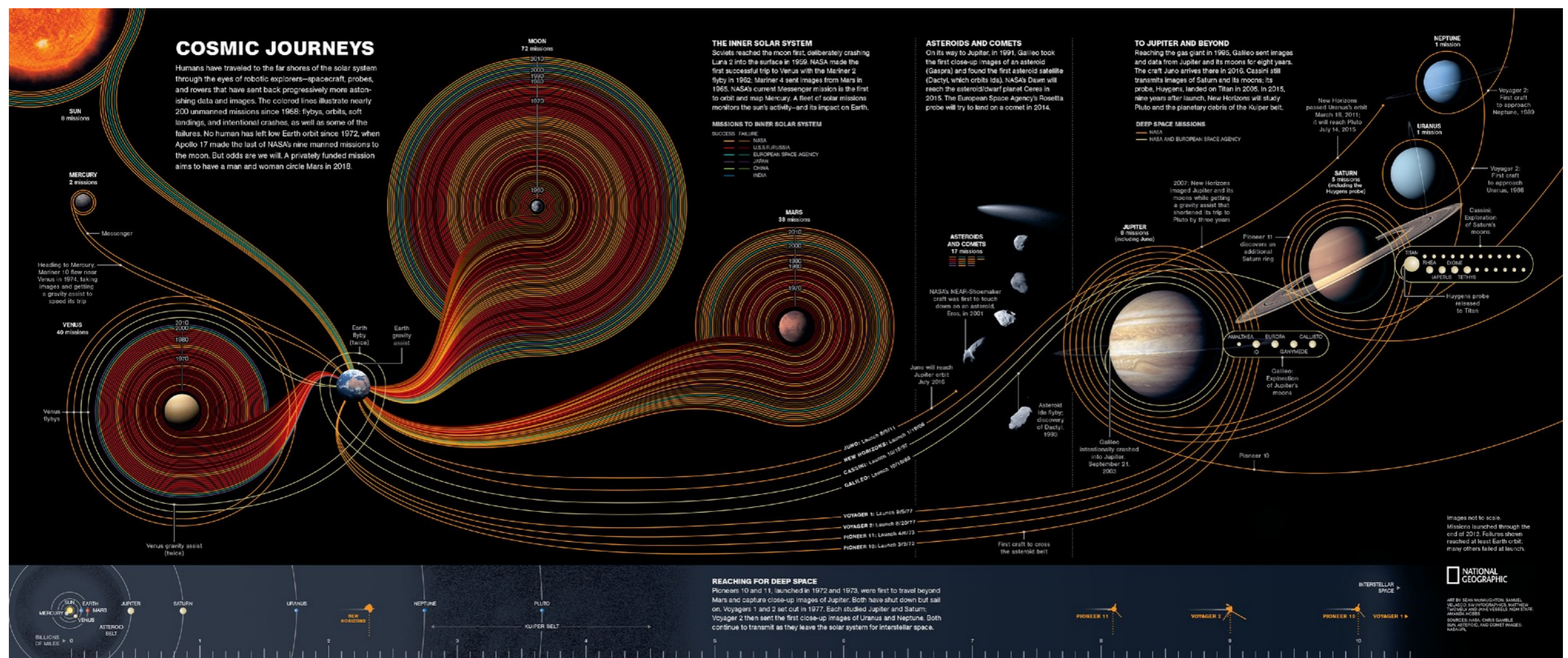
Ji-hoon Kim (Seoul National University)

Classical Mechanics I (Spring 2026): Quiz #20

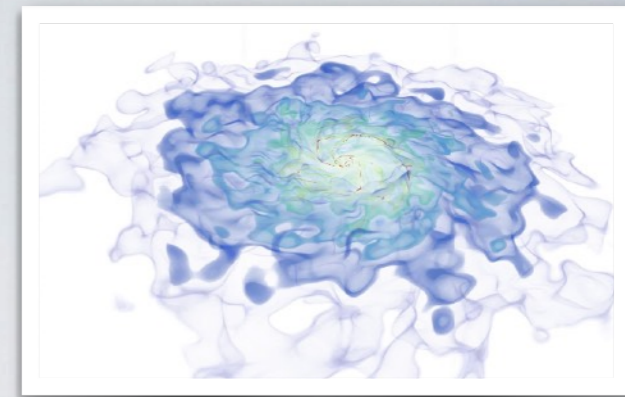
— [open book and open note, **but** no cellphone or laptop, submit to ETL **by 23:00pm, May 31**] —

Please write down your name and student ID in the top right corner. (0.0 pt: no paper found with your name / 0.5 pt: paper found with your name and some answers / 1.0 pt: good answers)

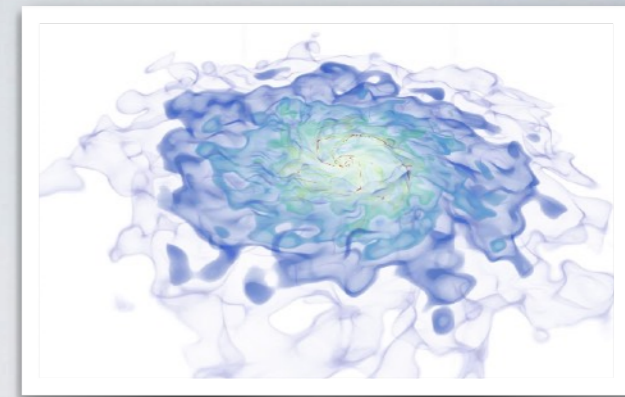
1. Thornton & Marion, Problem 7-33.
2. Thornton & Marion, Problem 7-28.



Probes sent by humankind into the solar system, National Geographic (2014)



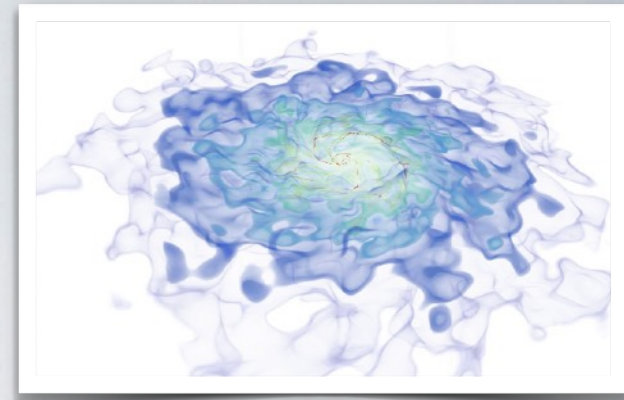
No TA Sessions In Week of 5/25



No TA Session on Jun. 3



Make-up TA Session on Jun. 1 (Mon)



Three Deadlines Before We Meet In Person On 6/2

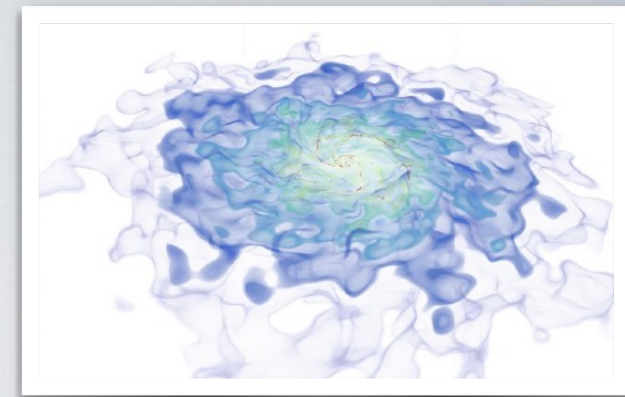
Term Project Presentation (Jun. 9)

- **Drag and drop** your slides as images **by 23:00pm, May 31 (Sun)** on a shared Google document below:

<https://docs.google.com/presentation/d/17HFeWg4uImH6Z-aXDSWxQhRqoiKSGJgDXc89C2qHRRg>

The screenshot shows a Google Slides presentation editor. The browser address bar displays the URL: <https://docs.google.com/presentation/d/1WDKFsYAo0a42OzpZAp6urkgAY2rFX6uqJhAfLvp...>. The slide thumbnail pane on the left shows a sequence of slides: slide 1 is blank with the text 'Student Name: John Doe'; slides 2, 3, and 4 are titled 'LIGO Gravitational Wave Signals' and contain diagrams of gravitational waves and a plot; slide 5 is blank with the text 'Student Name: John Doe'; and slide 6 is blank. The main editing area shows slide 1 with the text 'Student Name: John Doe'.

The screenshot shows the same Google Slides presentation editor, but with slide 2 selected. The slide title is 'LIGO Gravitational Wave Signals'. The content includes a bulleted list: 'Signals from distant events that distorted the spacetime fabric.' and 'A new window to the Universe opened up in addition to the good old electromagnetic window.' Below the text is a diagram of gravitational waves from two merging black holes, a map of the LIGO detector locations in the USA, and a plot of strain versus frequency. The plot shows a red line for the signal and a blue line for the noise floor. The plot is labeled 'Abbott et al. (2016a)' and 'www.jihoonkim.org'.



HW #4 has been posted!

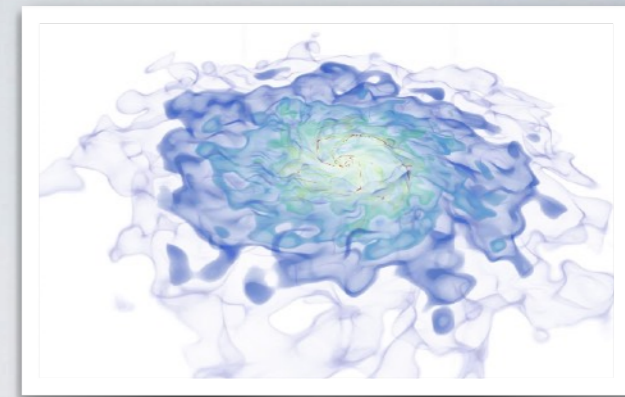
(To be posted on jihoonkim.org, Due: **Jun. 1 (Mon), 23:00pm**,

Grader TA this time: 서선기, supercap@snu.ac.kr)

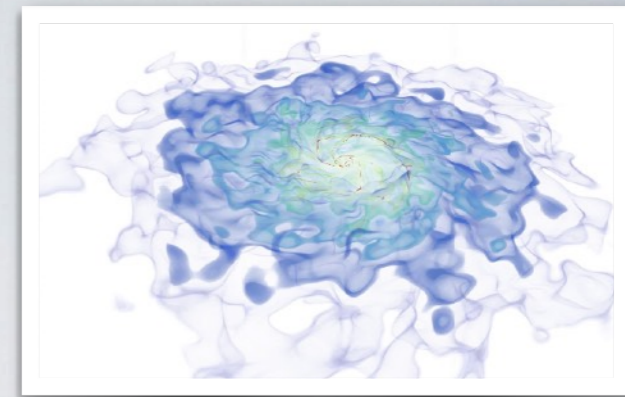
Term Project Paper

- Explore how ideas and methods from classical mechanics play a role in modern research or in everyday phenomena. Must approach the topic creatively and **incorporate your own original insights.**
- Due: Before the class starts on **Jun. 2nd**
(**10 page-limit** including cover/reference; typewritten report okay)



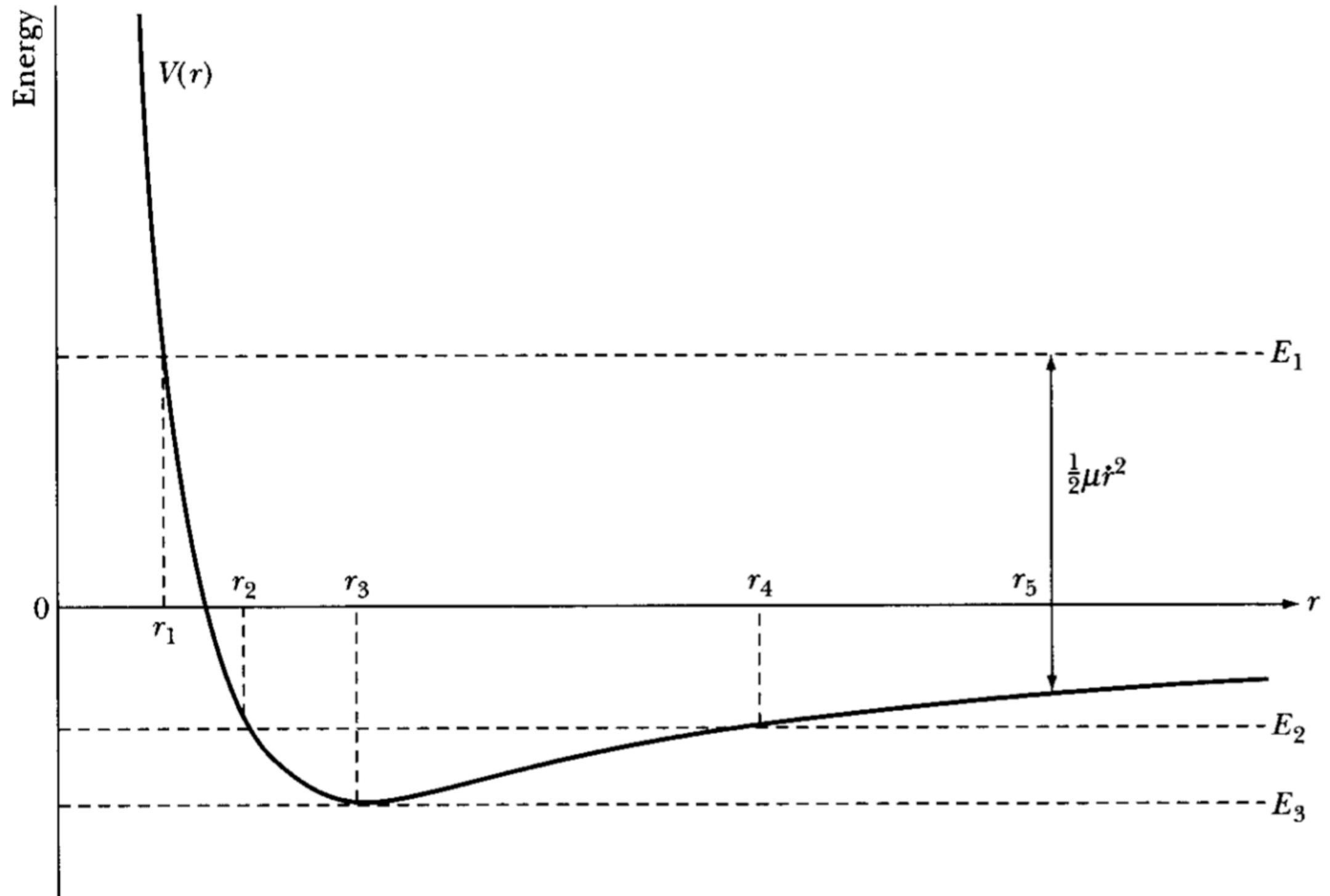


In the first page, please write down
the total time you spent to prepare
your report!

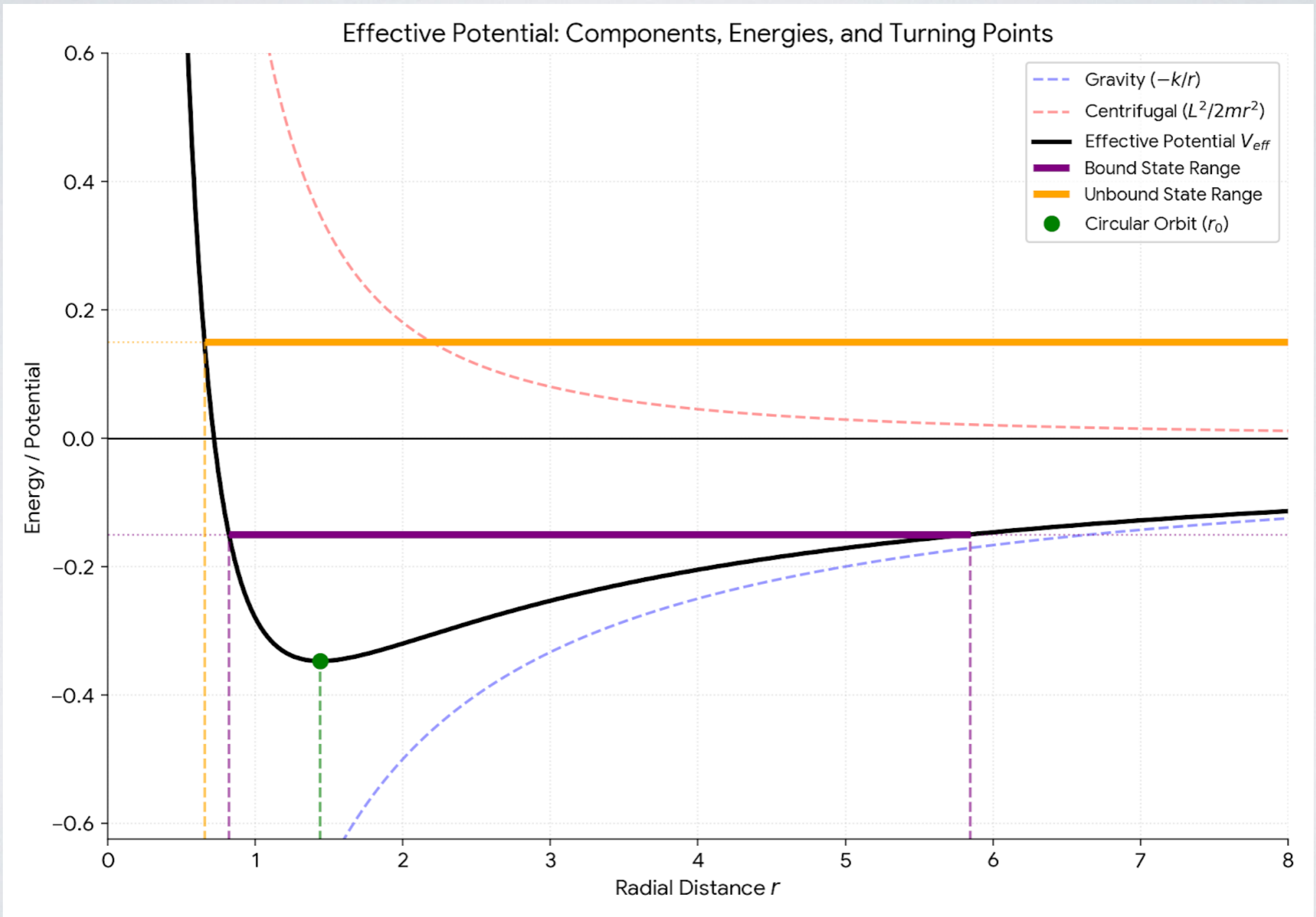


Effective Potential for Central Force

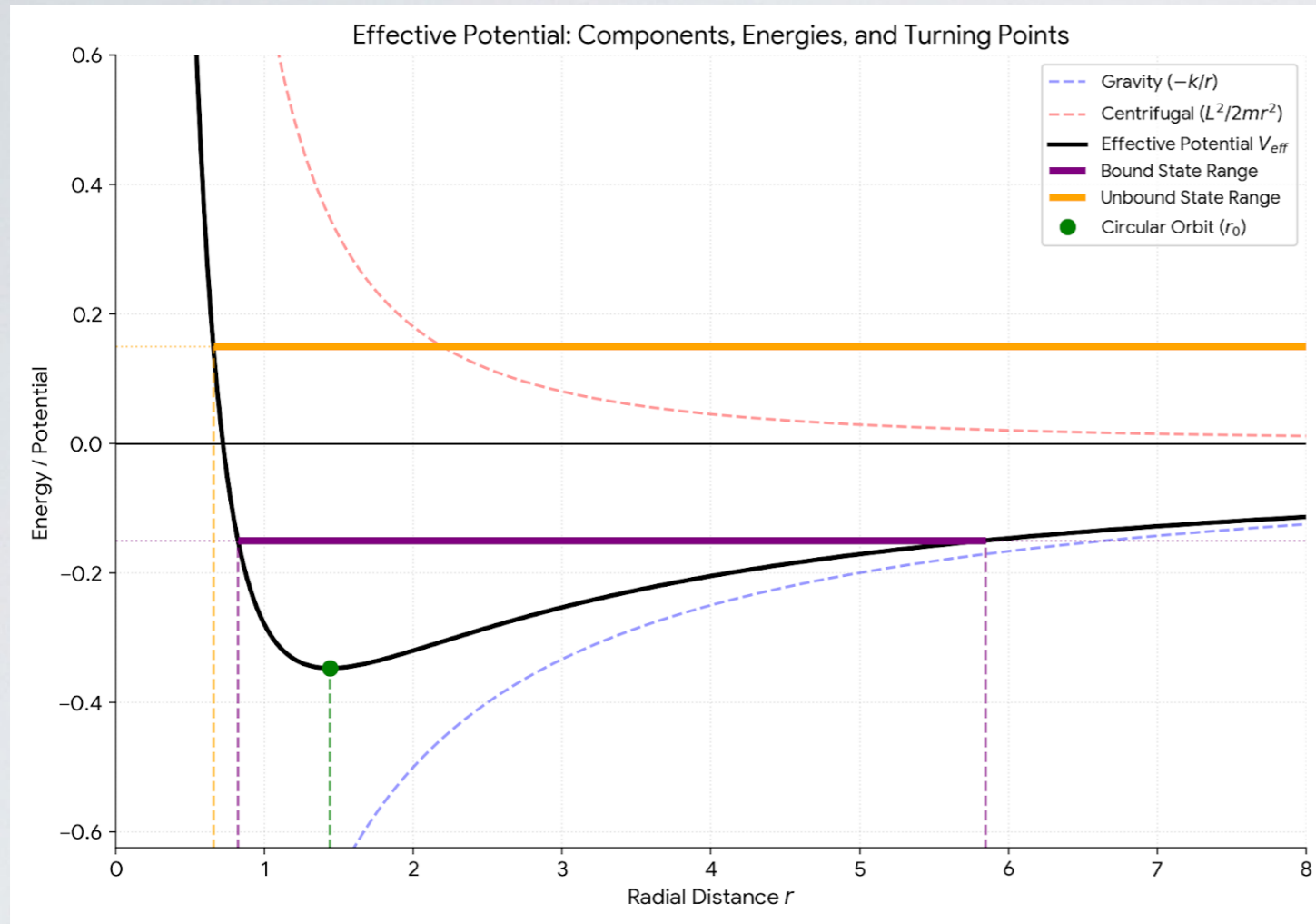
Effective Potential



Effective Potential



Effective Potential



[plots generated with vibe coding in python using Google Gemini]

```

import numpy as np
import matplotlib.pyplot as plt

# 1. Physics Constants
k = 1.0 # Force constant
L = 1.2 # Angular momentum
m = 1.0 # Mass

# 2. Define Potential Functions
def v_eff(r, k, L, m):
    return -k/r + L**2/(2*m*r**2)

def v_grav(r, k):
    return -k/r

def v_cent(r, L, m):
    return L**2/(2*m*r**2)

# 3. Setup Data Points
r = np.linspace(0.2, 8.0, 1000)
veff_vals = v_eff(r, k, L, m)
vgrav_vals = v_grav(r, k)
vcent_vals = v_cent(r, L, m)

# 4. Calculate Key Points
# Circular orbit (Minimum of V_eff): r0 = L^2 / (mk)
r0 = L**2 / (m * k)
v_min = v_eff(r0, k, L, m)

# Energy levels for visualization
E_bound = -0.15
E_unbound = 0.15

# Solve for turning points (2mEr^2 + 2mkr - L^2 = 0)
coeffs_bound = [2*m*E_bound, 2*m*k, -L**2]
roots_bound = np.sort(np.roots(coeffs_bound))
rmin_b, rmax_b = roots_bound

coeffs_unbound = [2*m*E_unbound, 2*m*k, -L**2]
roots_unbound = np.roots(coeffs_unbound)
rmin_u = np.max(roots_unbound[roots_unbound > 0])

# 5. Plotting
plt.figure(figsize=(10, 7))

# Components (Dashed lines)
plt.plot(r, vgrav_vals, '--', color='blue', alpha=0.4, label='Gravity ($-k/r$)')
plt.plot(r, vcent_vals, '--', color='red', alpha=0.4, label='Centrifugal ($L^2/2mr^2$)')

# Total Effective Potential (Solid black line)
plt.plot(r, veff_vals, 'k', linewidth=2.5, label='Effective Potential $V_{eff}$')

# Bound State Energy and Range
plt.axhline(E_bound, color='purple', linewidth=1, linestyle=':', alpha=0.5)
plt.hlines(E_bound, rmin_b, rmax_b, colors='purple', linewidth=4, label='Bound State Range')
plt.vlines([rmin_b, rmax_b], v_min*2, E_bound, colors='purple', linestyle='--', alpha=0.6)

# Unbound State Energy and Range
plt.axhline(E_unbound, color='orange', linewidth=1, linestyle=':', alpha=0.5)
plt.hlines(E_unbound, rmin_u, 8.0, colors='orange', linewidth=4, label='Unbound State Range')
plt.vlines(rmin_u, v_min*2, E_unbound, colors='orange', linestyle='--', alpha=0.6)

# Circular Orbit Marker
plt.plot(r0, v_min, 'go', markersize=8, label='Circular Orbit ($r_0$)')
plt.vlines(r0, v_min*2, v_min, colors='green', linestyle='--', alpha=0.6)

# 6. Aesthetics and Labels
plt.title('Complete Effective Potential Diagram ($F = -k/r^2$)', fontsize=14)
plt.xlabel('Radial Distance $r$', fontsize=12)
plt.ylabel('Energy / Potential', fontsize=12)
plt.ylim(v_min * 1.8, 0.6)
plt.xlim(0, 8)
plt.grid(True, which='both', linestyle=':', alpha=0.3)
plt.axhline(0, color='black', linewidth=1)
plt.legend(loc='upper right', frameon=True, shadow=True)

plt.tight_layout()
plt.show()

```